VOLUME I
PART I

OPERABLE UNIT REMEDIAL INVESTIGATION FOR MONTGOMERY TOWNSHIP HOUSING DEVELOPMENT SITE

Prepared for:

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Site Management
Division of Hazardous Site Mitigation
Trenton, New Jersey 08625

Draft 1

June 1987

86C4290

Submitted by:

WOODWARD-CLYDE CONSULTANTS
201 Willowbrook Boulevard
Wayne, New Jersey 07470

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15 June 1987
87C4290

New Jersey Department of Environmental Protection
Bureau of Site Management/DHSM
401 East State Street, Room 622
Trenton, New Jersey 08625

Attention: Mr. Kevin Psarianos

Re: Operable Unit Remedial Investigation/Feasibility Study
Montgomery Township Housing Development
Somerset County, New Jersey

Gentlemen:

Woodward-Clyde Consultants is pleased to submit this proposal to conduct an Operable Unit Remedial Investigation/Feasibility Study for the Montgomery Township Housing Development Site in Somerset County, New Jersey on behalf of Metcalf & Eddy, Inc. and Woodward-Clyde Consultants. It is our hope that this report meets the goals and objectives of the NJDEP.

If you have any questions regarding this report, please do not hesitate to contact us.

Very truly yours,

Robert G. Gaibrois
Project Manager

RGG:ad
Enclosure
RB87-133L

MTH 001 0612

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SECTION ONE
EXECUTIVE SUMMARY

In 1979 it was discovered that approximately one half of the private domestic wells in the Montgomery Township Housing Development (MTHD) were contaminated with trichloroethene (TCE) and other halogenated hydrocarbons. Initial findings prompted the United States Environmental Protection Agency to place the MTHD and a neighboring TCE contaminated site - Rocky Hill Municipal Wellfield - on the National Priority List (NPL) of hazardous waste sites. In 1984 Woodward-Clyde Consultants (WCC) was contracted by the New Jersey Department of Environmental Protection (NJDEP) to perform a Remedial Investigation/Feasibility Study (RI/FS) of both sites. This report represents an operable unit RI/FS to define the need and present recommendations for response to contaminated ground water in the private wells still in operation at the Montgomery Township Housing Developments.

In an effort to define a possible source or sources of the contamination, WCC initiated a sampling program involving ground-water, surface-water, soil and air sampling. Results from the first phase of this sampling program have revealed that an arcuate plume of contaminants extends from near the Rocky Hill Municipal Well north to Sycamore Lane and from Route 206 east to the Millstone River. Concentrations of TCE within the plume range from below detection (5 ug/l) to 650 ug/l. Based on calculated ground-water velocities it is impossible to discern whether the source or sources of contaminants is/are no longer present or whether the source/s is/are still releasing contaminants. Work is presently underway to better delineate the plume and investigate possible sources of contaminants.

Results of this study have shown that residents of the MTHD that have chosen to continue using their private wells are using water containing hazardous substances whose concentrations are in excess of those levels deemed to be safe by various health authorities. The feasibility of several alternatives for drinking water sources has been studied by Metcalf and Eddy, Inc. Alternatives were considered with respect to public health protection, environmental impacts, technical feasibility and cost. Based on their study the most feasible remedy would be to extend the Elizabethtown Water Company distribution system and connect those residences where private wells are currently supplying drinking water.

Although not all wells are contaminated above [illegible] potential exists [illegible] fluctuation of levels above standards. Levels [illegible] fluctuated. [illegible] would be to [illegible] wells from operation.

- Description of alternatives

SECTION TWO
INTRODUCTION

In 1979 it was discovered that water from the Rocky Hill Municipal Well, Rocky Hill, New Jersey, was contaminated with trichloroethene (TCE). The well was closed and Rocky Hill residents were provided an alternate water source. Subsequently, the well was attached to an airstripper and reopened. The discovery of contaminants in Rocky Hill prompted the sampling of 71 nearby private wells located in the Montgomery Township Housing Development (MTHD). Approximately half of these wells were found to be contaminated with TCE and other halogenated hydrocarbons. Within a year of the initial testing, Elizabethtown Water Company water lines were installed throughout the MTHD. At that time residents were given the option of connecting to the public water supply.

Both the Rocky Hill Municipal Wellfield site (RHMW) and the MTHD were placed on the United States Environmental Protection Agency's National Priority List of hazardous waste sites. Because of the proximity of the RHMW to the MTHD it was decided that the two sites be studied simultaneously under one contract. In 1985 Woodward-Clyde Consultants, Inc. was awarded a contract to conduct a Remedial Investigation/Feasibility Study of the sites to determine potential sources and solutions to the contamination problem. This report represents the results of this study to date pertaining to the MTHD. A final report to be issued in the future will include results of the final phase of work at MTHD and all results from the RHMW study.

This report is issued in two volumes. Volume I contains background information on previous investigations (Section 3), a discussion of field methodologies employed in this study (Section 4), and a presentation and evaluation of the geophysical survey, geotechnical borings, and the ground water investigation (Section 5). The ground water investigation included installation of monitoring wells, aquifer testing, and sampling and analysis of monitoring and domestic wells. Results of all of these facets of the investigation are integrated in Section 6 and summarized in Section 7.

Volume 2 contains the risk assessment and feasibility study for the MTHD site. This study was prepared according to the New Jersey Department of Environmental Protection (NJDEP) Draft Risk Assessment Guidelines for Hazardous Waste Sites (NJDEP, 1986).

SECTION THREE
SITE BACKGROUND INFORMATION

3.1 SITE LOCATION AND LAYOUT

3.1.1 Montgomery Township Housing Development

3.1.1.1 Location. Montgomery Township Housing Development is a 72 acre tract of land in Montgomery Township, Somerset County, New Jersey. The site is located at 74°35'0" west longitude and 40°24'0" north latitude.

The housing development is located east of Route 206, north of Route 518, west of the Millstone River, and south of Beden Brook and Montgomery Road.

3.1.1.2 Site Layout. As shown on Figures 3-1 and 3-2, the adjacent properties to the north of Sycamore Avenue are wooded or agricultural lots. To the southwest are an office center (former site of two suspect sources) and two shopping centers. To the south is the Borough of Rocky Hill (population 960) which is primarily residential. A cemetery lies between the borough and the development, off of Montgomery Road. The homes on the end of Cleveland Circle are bordered to the east by the Millstone River, which parallels the Delaware and Raritan Canal. To the north of Montgomery Road lies the Ingersoll-Rand plant.

The development itself consists of 71 approximately 1-acre home sites situated on Sycamore Lane, Robin Drive, Oxford Circle, and Cleveland Circle. Sycamore Lane has generally an east-west orientation. The highest point, 140 ft above mean sea level (MSL), is at the end of Robin Drive and the lowest point, 60 ft above MSL, is at the end of Cleveland Circle.

3.1.2 Rocky Hill Municipal Wellfield

3.1.2.1 Location. The Rocky Hill Municipal Wellfield is a 2-acre tract of land in the Borough of Rocky Hill, Somerset County, New Jersey. The site is located at 40°24'0" North latitude and 74°38'0" West longitude.

The wellfield is located to the east of New Jersey Route 206 and just south of NJ Route 518. Local tax maps identify the property as Block 5, Lot One.

3.1.2.2 Site Layout. The wellfield (Figure 3-3) is bounded on the north by residences fronting on Route 518 (also known as Washington Street). Immediately west of the site is a commercial center. The wellfield is bounded on the east by townhouses and undeveloped fields. An open field (formerly an aircraft landing strip) lies southeast of the wellfield, and Princeton Airport is approximately 2,000 ft southwest of the site.

Most of the property in the general vicinity of Rocky Hill is moderately developed residentially or commercially. The only undeveloped area within one-half mile of the site is the open field southeast of the site.

Two structures containing wells are located on the wellfield, one housing the functioning well and one that has been abandoned. In addition, two air stripping units have been constructed and are operational, having a combined capacity of 250 gallons per minute. The air stripping units required an extension on the building housing the functional well (Well Number 2). The Borough received approval on July 27, 1983 to resume pumping this well (Merk, 1983). Potable water is stored in a 100,000 gallon water tower located adjacent to the well house building.

Presence of contaminants besides TCE is not discussed.

3.2 SITE HISTORY

3.2.1 Montgomery Township Housing Development

Tax records and accompanying maps indicate that the housing development site was owned by Harry A. Hey (50.59 acres) and D.B. Hamman (33 acres) until 1961. The land was used for farming and there is no knowledge of any underground tanks or landfill areas on the property at that time. Tri State Development Corp., owned by Mr. Charles Egner, purchased the land in 1961 (Grayson, 11 July 1983).

Construction on the homes began in 1961 and the area was divided into 71 lots with wells and septic tanks. In 1978, a 208/201 study by Rutgers University on the Rocky Hill Borough well revealed trichloroethene (TCE) contamination levels of 25 ppb. Continued testing of this water supply revealed that by November 1979, TCE contamination had increased to 400-500 ppb. About this time, the residents were advised not to use the water, and the borough began receiving Elizabethtown Water Company water. Concern over the ground water contamination in Rocky Hill spurred the initial sampling of individual wells in Montgomery Township from December, 1979 to January 1980 (Searfoss, 7 July 1983).

3.2.2 Rocky Hill Municipal Wellfield

Wells Number 1 and 2 were completed in 1936 (Greenfield, 1937). These two wells provided a source of potable water to the Borough of Rocky Hill. Well Number 1, located on the southern portion of the wellfield, was abandoned and sealed between 1976 and 1978. Because of elevated levels of TCE in the water of Well Number 2, this well was also shut down on 14 November 1979 (Trenton Times, ~~1979~~). Levels of TCE in the well water eventually declined, and the well was subsequently approved in July 1981 by NJDEP as a municipal water supply (The Princeton Packet, 1981). Levels of TCE, however, increased, and the well was shut down for a second time in January 1982 (Geoghan, 1982). During the shutdown of Well Number 2, Rocky Hill Borough obtained potable water from the Elizabethtown Water Company. The borough, however, recently completed the installation of two air stripping units for Well Number 2, and the well was reopened as a potable source of water on 27 July 1983 (Merk, 1983).

3.3 ENVIRONMENTAL SETTING

3.3.1 Geology

3.3.1.1 Unconsolidated Deposits. The MTHD site lies in the Piedmont Physiographic Province and is underlain by bedrock of the Brunswick Formation covered with a relatively thin (up to about 30 ft thick) veneer of unconsolidated sediments. The unconsolidated sediments predominantly consist of residual soil formed by weathering of the underlying bedrock. The residual soil generally is composed of clay, silt, and fragments of unweathered shale. Pre-Wisconsin, possibly Jerseyan, glacial deposits, which include glacial till or gravels have also been noted in the area. Exposures of glacial till have been mapped on hill crests in the Rocky Hill lowland (Neuman, 1980). This till defines a drift border in the vicinity of Rocky Hill. A 12 ft thick exposure of the till near the Montgomery Shopping Center is a heterogeneous boulder-gravel-clay deposit.

3.3.1.2 Bedrock: Brunswick Formation The Brunswick Formation is the youngest, thickest, and most extensive unit of the Newark Group of late Triassic Age. In the area of interest, the Brunswick Formation consists of varying thicknesses of red shale, mudstone, siltstone, sandstone, and argillite. The Brunswick Formation is usually weathered to a depth of several feet where it consists of clay with rock fragments.

South of Rocky Hill, the bedrock consists of diabase. The contact between the Brunswick Formation and the diabase trends northeast-southwest, consistent with the regional structural trend. At the contact with the diabase intrusion, the shale is contact metamorphosed to hornfels.

The strike of the Brunswick Formation bedding is generally northeast; dips are generally in the range of 13 to 12° NW. Several topographic features in the vicinity of the project have a nearly east-west trend suggesting fracturing/jointing in this direction. Locally, the strike of these beds differs markedly from the regional northeasterly trend.

The following fracture systems resulting from jointing have been reported:

- vertical or near vertical fractures that generally parallel the strike of the bedding;
- vertical or near vertical fractures that are generally perpendicular to the strike;
- occasional steeply dipping joints that cross-cut the aforementioned two systems; and
- bedding-plane joints which are common in surface exposures.

Major and minor faults also occur in the rocks of the Newark Group, with most of the faults trending northeastward.

3.3.2 Hydrology

3.3.2.1 Ground Water. Regionally, the Brunswick Formation is the principal aquifer. Ground water exists in a number of water-bearing zones which are generally under unconfined to semi-confined conditions. Semi-artesian and artesian conditions can occur locally where marked differences exist in the vertical permeability of the formation. Artesian conditions also exist in some lowland areas, where the Brunswick Formation is overlain by relatively impermeable clayey soils.

The intersecting fractures that have resulted from the jointing provide the principal means of storage and movement of ground water in the Brunswick

Formation. This is supported by observations made in several long tunnels through the bedrock, where frequent streams of water were reportedly observed to follow vertical fissures, whereas the bedding planes were nearly dry.

Data collected during pumping tests of wells throughout the outcrop area indicate that the aquifer in the Brunswick Shale possesses anisotropic hydraulic properties related to the structure of the formation (Vecchioli, 1967). This is based on the field observation that wells aligned parallel to the strike of the Brunswick Shale exhibited greater drawdown than other wells during pumping tests. For example, measurable drawdown was reported in monitoring wells located a mile away from a pumping well along the strike of the Brunswick Formation.

Vecchioli, *et al.* (1969) indicate that the degree of anisotropy in hydraulic properties of the Brunswick Shale is spatially variable. In some areas, it is considerably less anisotropic than in others, and locally may even be nearly isotropic. Nonetheless, according to these authors, the drawdown during pumping is found to be always greatest along strike.

The practical implication of the directional hydraulic behavior of the Brunswick aquifer, in our case, is that if the ground water is able to flow more freely in the direction of strike, then the facility for contaminant migration would be greatest along strike. Such a condition was observed in Newark, New Jersey, where elongated tongues of salt water have encroached in directions parallel to strike (Herpers and Barksdale, 1951).

3.3.2.2 Water-Supply Wells The ground water in the Brunswick Shale is extensively pumped for domestic and industrial use. Table 3-1 indicates that more than 90 such wells were installed within a 1-mile radius from the center of the area of study. Locations of these wells are illustrated in Figure 3-4. The sum of the reported yields of these water-supply wells is on the order of 2,000 gpm.

3.4 PREVIOUS INVESTIGATIONS

3.4.1 Previous Remedial Response Activities

Response activities for ~~the Montgomery~~ Township Housing Development Site + Rocky Hill have been undertaken by NJDEP since 1979. A summary of these activities is presented in Appendix A. — Should be to present

The previous response activities included:

- o physical remedial action
- o sampling and testing of:
  - water from private wells
  - water from industrial water-supply wells
  - soil at potential responsible parties' sites and background soils
  - water from surface-water bodies
  - septic tanks
  - industrial effluent
  - industrial storage drums
  - industrial tanks
  - Elizabethtown Water Company water
  - stream sediments

Physical remedial action included, for example:

o Shutting down of RHW 1

- o Installation of Elizabethtown water lines in March, 1981;
- o Shutting down of Rocky Hill Municipal Well No. 2 in November, 1979;
- o Reactivation of Rocky Hill Municipal Well No. 2 in July, 1981;
- o Shutting down of Rocky Hill Municipal Well No. 2 in January, 1982 after switching back to the Elizabethtown water supply;

- o Reactivation of Rocky Hill Municipal Well No. 2 in February, 1982;
- o Performance of air-stripping pilot tests on RHMW No. 2 in July, 1983;
- o Installation of home water-purifying devices by residents of Montgomery Township Housing Development who elected to do so.

Sampling-and-testing results are provided in Appendix B separately for MTHD and RHMW. A chronology of testing for TCE in the MTHD wells is presented in Appendix C. The results are discussed in conjunction with recent data in Section 5.3.

3.4.2 Potential Sources of Contamination

The NJDEP files included information on industrial and commercial establishments within the site area which are believed to be potential sources of contamination (Potentially Responsible Parties, PRPs). Some of the PRPs have on-site wells which have been sampled and for which analytical data was available. Records of the PRPs and NJDEP-DWR indicated that several hazardous substance losses, potentially having environmental impact, occurred between 1970 and 1979. However, conclusive evidence does not exist in the background information connecting one or more of the PRPs to the trichloroethene (TCE) and other volatile organic compounds (VOC) found in the ground water. In addition to the establishments listed below, domestic and/or commercial septic systems have been cited as a potential point or nonpoint source of contamination. (See Section 3.4.3.4.)

Because there is a possibility that the potential source or sources of ground water contamination might be the same for both the MTHD and the RHMW, these sources are listed together. There are a number of potential industrial or commercial sources of ground water pollution in Montgomery Township and the Borough of Rocky Hill within one mile of the housing development and the municipal well that were identified by NJDEP. A brief description of some of the potential industrial and commercial sources is presented below.

- Texaco Station - This service station is located at the northwest corner of Routes 206 and 518. It has a septic tank for sanitary waste, a 550 gallon underground tank for waste oil, and a small solvent reclamation system.

- Mobil Station (also known as Collin's Garage) - This service station is located at the northeast corner of Routes 206 and 518. It has a septic tank for sanitary wastes and a 275 gallon underground waste oil tank. No solvents are used (Wishart, 14 December 1979). Thul's Auto Body is adjacent to the station. Thul's is an auto parts store and there may be some machining and use of solvents or degreasers.

- William Penn - This service station is located at the southeast corner of Routes 206 and 518. It has a septic tank for sanitary waste, a 550 gallon inground waste oil storage tank, and a small, self-contained reclamation system for solvents (Wishart, 14 December 1979).

- Princeton Volkswagen - This establishment is located on the west side of Route 206, 300 yards south of Route 518 and 330 yards west of the Rocky Hill municipal well. The facility uses the municipal sewer system, a 1,000 gallon underground waste oil tank, and a small solvent recovery system. No test data are available for this site (Wishart, 14 December 1979).

- Princeton Airport - The airport, owned by Princeton Aero Corp., is located one-half mile southwest of the Route 206 and 518 intersection. The facility has a 250 gallon above ground waste oil tank, an underground airplane fuel storage tank, and a self-contained solvent system (Wishart, 14 December 1979). An oil-water separator has, at times, not been operating properly, and has spilled its contents onto surrounding soil. A staging area for waste oil drums had also contaminated immediate soils. The underground gasoline storage tank has been removed. Sampling has been conducted at several well and soil sites. Trenches have been dug around the gasoline tank for water and sediment analysis. Airport personnel installed nine monitoring wells on site.

- Princeton Chemical Research (PCR) - This facility has been renovated as the 1377 Office Building and now has several tenants. It is located on the east side of Route 206 north of the Route 518 intersection. While it operated as Princeton Chemical Research, the facility mixed milled and extruded rubber compounds into golf balls, and manufactured pyromellitic dianhydrides, BDTA, and other specialty chemical products. Aside from ground-water contamination problems detected in the on-site wells, there is also an area of PCB-contaminated soil adjacent to the back door of the plant. In addition, Public Utility electric transformers lie adjacent to the site. There was a tank farm to the rear of the site and an area reportedly used for spray waste irrigation. The plant has a history of environmental problems including a chemical spill into Beden Brook (1972) and a resultant fish kill (Jacangelo, 14 January 1974). The septic tank, two abandoned wells, and four levels of soil have been sampled for volatile halogenated compounds and PCBs. The state installed a background monitoring well at the Village Shopper (across Route 206 from PCR).

- Polycell - This facility, owned by Rocky Hill Realty, was located on the east side of Route 206 north of Route 518 and just south of

PCR. The facility was in the plastic extrusion business but was destroyed by fire about eight years ago. The four conduit lines that were located on site contained p-dichlorobenzene and hexachlorobutadiene. The abandoned well is still being used for monitoring purposes. State and township offices have very sketchy information on this operation (Searfoss, 7 July 1983).

- Compo Industries (also known as Ameliofex) - This facility was located on Crescent Avenue south of Route 518 in Rocky Hill Borough. The property is owned by Rocky Hill Partners. The operation has been discontinued as of its 1 July 1983 permit expiration date (Searfoss, 7 July 1983). The facility was engaged in the production of urethane resins and reclamation of spent dimethyl formide (DMF). The facility was connected to the municipal sewer system and directly discharged non-contact cooling water to the Millstone River. The two wells on the site are production wells. One NJDEP monitoring well is on the adjacent property. Although TCE has been found in the deeper Compo well, it was not one of the raw materials used by Compo or the previous two tenants, Amelotex or Hercules, Inc. (Wishart, 14 December 1979). Effluent sample tests from Compo operations at the Millstone River discharge revealed high levels of several volatile materials including toluene, methyl ethyl ketone, and xylene (Bruns, 6 April 1981, 13 April 1981). There were about 500 drums of chemical waste and several abandoned tank trailers on the site. Some of the drums were noted to be leaking. The drums have been removed to an off-site location.

- Princeton Gamma Tech - This facility is located on the north side of Route 518 just east of the Route 206 intersection. This facility manufacturers radar detection equipment and lab analysis equipment. The building is serviced by a large septic system used for the disposal of sanitary and lab sink waste (Wishart 14 December 1979). The lab had used TCE (1-2 gallons per month) in the past, and although policy was to store the spent solvent in containers for later reclamation, some may have been disposed of improperly. The well, septic tank, aeration tank, and several soil horizons have been sampled and tested for chlorinated hydrocarbons. The septic tank was found to have TCE concentrations of 8900 ppb (Miller, 2 April 1980). NJDEP ordered the tank to be emptied and cleaned and use was discontinued until satisfactory sample results were obtained.

- Ingersoll Rand Corp. - This facility is located on Montgomery Road, northeast of the development, and adjacent to Millstone River. The facility does testing and research of drilling equipment. The plant has its own sewage treatment facility for domestic waste. Some TCE has been used as a degreaser for the machinery. There is a private potable water well on the property (Wishart 14 July 1979).

- Montgomery Township Shopping Center - This shopping center is owned by Rocky Hill Realty and is located approximately 600 ft north of Route 518 on Route 206 Each. Elevated concentrations have been recorded in the septic system at the shopping center (NJDOH, 1980).

3.4.3 Previous Analytic Results

3.4.3.1 Soil Quality. Only limited data are available describing soil contamination at industrial and commercial sites that are potential sources.

Results of soil sampling at selected industrial and commercial facilities presented in MTHD RAMP indicate that:

- Princeton Chemical Research has soil contaminated with PCBs and (methylene chloride).
- Princeton Airport has areas where soils are contaminated with volatile organic compounds.
- Princeton Gamma Tech had no contamination detected in soil samples collected to a depth of 21 ft.

3.4.3.2 Ground-Water Quality Ground-water quality was extensively studied by NJDEP. Several rounds of sampling and analytical testing were conducted from municipal, private, industrial and commercial wells. Analytical results were presented in the RAMPs dated 1984 and are summarized in Appendix B. Figure 3-5 and Table 3-2 present ground water and well information not contained in the RAMPs including:

no data pre RAMP + post RAMP data

- Location and depth of wells used as sampling points[1].
- Approximate location of sampling trench T2 at the Princeton Airport.
- Water-supply wells known to be presently operating.

The following data were not available from the information sources review:

- Pumping data on existing water supply wells.
- Hydrologic data concerning ground water flow and ground water table fluctuations

[1]. Includes two NJDEP monitoring wells, water-supply wells at potential sources of contamination, the Rocky Hill Municipal Wellfield, and MTHD private wells with the highest TCE concentration in ground water.

Why weren't septic samples at these homes where elevated TCE conc. had been determined?

To identify any trends in the levels of TCE contamination in the MTHD wells, all available TCE concentrations for each homesite in the MTHD were tabulated and mapped (Figure 3-5 and the table in Appendix C). These data indicate that:

- o Homes at Cleveland Circle have the highest TCE concentrations, and the homes at the ends of Robin Drive and Oxford Circle have the next highest concentrations. (Figure 3-5 presents the highest TCE concentrations at each homesite.)
- o With some exceptions, the TCE concentrations did not vary significantly with time for each homesite well in MTHD.

The RAMP concluded the following:

Over 30 homes [illegible]

- o The bulk of the analytical information documents a serious ground-water pollution problem in Montgomery Township. Monitoring of the housing development wells has indicated that 25 percent of the wells exceed 50 ppm TCE. These 18 wells service a population of 56 residents. Only 20 homes are currently connected to the Elizabethtown Water Supply. Figure 3-6 shows the location of these homes. The remaining homes may be either using bottled water or still using their well water. One household has purchased a Culligan filter to treat its raw well water (Searfoss, 7 July 1983). Of the 51 residences which have not connected to public water, 6 have shown TCE levels above 150 ppb, 6 have shown TCE levels of 50 to 99 ppb, and 21 have shown TCE levels of 1 to 24 ppb.

March 1986 - DWR: restricted wells 8 new homes had to hook up to municipal supply

3.4.3.3 Surface Water/Effluent Discharge Analytical data for surface water and industrial effluent are limited to a small number of samples. Interpretation of variations in analytical results is not valid with such a small number of samples. Additional sampling and analysis would be required to generate data useful in assessing these waters are contaminant sources.

• Should provide evidence that septics are not a probable source of contamination: Use groundwater [illegible]

3.4.3.4 Septic Tanks Septic tanks of MTHD residents have never been sampled and were not tested for TCE and/or other contaminants. Therefore, these potential as sources of TCE (used commonly as a septic system cleaner) cannot be evaluated at this time.

Sampling of septic tanks at the industrial and commercial establishments summarized in the RAMPs indicates:

- Montgomery Shopping Center - volatile organic compounds were detected in concentrations up to 15,000 ppb. TCE was present in the greatest concentration in samples collected in 1980.
- Princeton Gamma Tech - TCE was detected at 8,900 ppb in 1979.
- Compo Industries - TCE was detected at 62 ppb in 1980.
- Princeton Chemical Research - TCE was detected at 95 ppb.
- Polycell - TCE was detected at 31.4 ppb in 1980. Four other organic compounds were detected at lesser concentrations.

At present, septic tanks, including residential, are being considered potential sources of contamination of the Brunswick Shale aquifer.

3.4.3.5 Air Quality Available air quality data from NJDEP-DWR, NJ Geological Survey and the site RAMP were reviewed. No on-site air quality data was found for RHMW. No information was found to indicate that air quality monitoring was performed to address potential TCE problems in either Montgomery Township or Rocky Hill Borough.

Include additional ← New
outside Mont. Twp. [illegible] → Yes

- Current: Up to 86

TABLE 3-1
INVENTORY OF EXISTING WATER WELLS WITHIN THE MONTGOMERY TOWNSHIP/ROCKY HILL STUDY CORRIDOR

Ref. No.	New Jersey Coordinate System Location No.	Reported Address	Original Owner	Date Drilled	Total Depth (ft)	Reported Yield (gpm)	Well Diameter (in)	Length of Casing Installed (ft)	Depth of Interval Screened (ft)	Length of Open, Uncased Section (ft)	Casing and Screen Material	Depth to Static Water on Date Drilled (ft)	Depth to Pumping Water Level (ft)	Use	Aquifer	Analyses of Well Water
1	28-2-445	Opossum Road, Montgomery Twp	Anthony Pinelli	20 Jul 1968	152	9	6	51	Unscreened	101	Steel	22	100	Domestic	Red Shale	Not Sampled
2	28-2-445	Opossum Road, Montgomery Twp	Joseph Tufano	6 May 1964	153	15	6	34	Unscreened	119	Steel	30	70	Domestic	Red Shale	Not Sampled
3	28-2-445	Opossum Road, Montgomery Twp	Richard Posey	2 Jun 1963	110	6	6	35	Unscreened	75	Steel	30	90	Domestic	Shale	Not Sampled
4	28-2-446	Montgomery Twp	Richard Bell	9 Mar 1956	130	15	6	32	Unscreened	98	Steel	22	70	Domestic	Sandstone	Not Sampled
5	28-2-452	Mt. Lucas Road, Princeton Twp	Arthur Bell	13 Aug 1952	94	4	6	23	Unscreened	71	Steel	16	70	Domestic	Sandstone	Not Sampled
6	28-2-452	Montgomery Twp	Lester Schlapfer	8 Aug 1953	195	20	6	33	Unscreened	162	Steel	45	95	Domestic	Shale	Not Sampled
7	28-2-456	Montgomery Twp	Louis Balestrieri	24 Nov 1962	148	9	6	31	Unscreened	117	Steel	20	100	Domestic	Red Shale	Not Sampled
8	28-2-458	Montgomery Twp	Henry Young	2 Nov 1953	102	6	6	34	Unscreened	68	Steel	15	80	Domestic	Red Shale	Not Sampled
9	28-2-467	Montgomery Twp	Henry Young	14 Nov 1951	88	10	6	22	Unscreened	66	Steel	48	48	Domestic	Shale	NA
10	28-2-468	Mongomery Road, Montgomery Twp	Ingersoll-Rand Research Center	16 Aug 1966	250	40	6	40	Unscreened	210	Steel	25	200	Laboratory	Bluish-Grey Shale	Not Sampled
11	28-2-468	Montgomery Road, Montgomery Twp	Ingersoll-Rand Research Center	3 Aug 1966	250	30	6	NA	Unscreened	NA	Steel	40	200	Laboratory	Bluish-Grey Shale	Not Sampled
12	28-2-468	Montgomery Road, Montgomery Twp	Ingersoll Rand Research Center	30 May 1985	506	125	10	40	Unscreened	466	Steel	11	100	Laboratory	Red Shale	NA
13	28-2-471	Montgomery Twp	William T. Lord	23 May 1955	204	NA	6	24	Unscreened	180	Steel	32	90	Domestic	Red Shale	Not Sampled
14	28-2-471	Montgomery Twp	Albert Nico	24 Feb 1954	113	10	6	21	Unscreened	92	Steel	39	39	Domestic	Shale	Not Sampled
15	28-2-472	Opossum Road	Guy Divislo	9 Feb 1973	240	8	6	52	Unscreened	188	Steel	5	150	Domestic	Red Shale	Not Sampled
16	28-2-472	Opossum Road	Michael Tomasi	3 Aug 1963	160	3	6	35	Unscreened	125	Steel	30	130	Domestic	Red Shale	Not Sampled
17	28-2-474	Rt. 518, Montgomery Twp	Brain Bio-Center	19 Jun 1980	150	70	6	25	Unscreened	80	Steel	50	50	NA	NA	NA
18	28-2-475	Rocky Hill Road, Montgomery Twp	R.L. Hunt	16 May 1956	90	15	6	42	Unscreened	48	Steel	26	55	Domestic	Shale	Not Sampled
19	28-2-475	Rt. 518, Montgomery Twp	Clifford Dunn	16 Jun 1953	130	8	6	33	Unscreened	97	Steel	32	70	Domestic	Red Shale	Not Sampled
20	28-2-476	Montgomery Twp	Donald Perkins	24 Aug 1956	127	8	6	30	Unscreened	97	Steel	35	70	Domestic	Red Shale	Not Sampled
21	28-2-479	Mountain View Rd, Montgomery Twp	John Bocchino	2 Dec 1976	240	15	6	50	Unscreened	190	Steel	50	150	Domestic	Bluish-Grey Shale	Not Sampled
22	28-2-482	Rt. 206, Montgomery Twp	NJDEP, Water Resources	5 Feb 1982	75	10	4	20	Unscreened	55	Steel	5	NA	Monitoring	NA	NA
23	28-2-483	Montgomery Twp	Charles Egner	10 Dec 1962	142	9	6	46	Unscreened	96	Steel	30	70	Domestic	Red Shale	Not Sampled
24'	28-2-483	NA	Tri-State Development Co.	10 Jun 1965	158	10	6	43	Unscreened	115	Steel	67	80	Domestic	Red Shale	Not Sampled
25	28-2-483	Montgomery Twp	Mundy-Nestler, Inc.	16 Dec 1963	122	9	6	47	Unscreened	75	Steel	45	70	Domestic	Shale	Not Sampled
26	28-2-484	Rt. 518, Montgomery Twp	Alexander Ried	4 Jan 1956	129	8	6	33	Unscreened	96	Steel	35	70	Domestic	Red Shale	Not Sampled

TABLE 3-1, CONTINUED

Ref. No.	New Jersey Coordinate System Location No.	Reported Address	Original Owner	Date Drilled	Total Depth (ft)	Reported Yield (gpm)	Well Diameter (in)	Length of Casing Installed (ft)	Depth of Interval Screened (ft)	Length of Open, Uncased Section (ft)	Casing and Screen Material	Depth to Static Water on Date Drilled (ft)	Depth to Pumping Water Level (ft)	Use	Aquifer	Analyses of Well Water
27	28-2-484	Montgomery Twp	Charles Egner	4 Dec 1961	100	10	6	36	Unscreened	64	Steel	20	80	Domestic	Red Shale	Not Sampled
28	28-2-485	Montgomery Twp	Rocky-Hill Realty	14 Sept 1964	150	40	6	33	Unscreened	117	Steel	25	120	Domestic	Red Shale	Not Sampled
29	28-2-485	Montgomery Twp	Edmund Schuster	31 Aug 1961	122	10	6	45	Unscreened	77	Steel	30	52	Domestic	Shale	Not Sampled
30	28-2-486	Montgomery Twp	Rocky-Hill Realty	31 Oct 1963	150	40	6	45	Unscreened	105	Steel	30	80	Domestic	Red Shale	Not Sampled
31	28-2-486	Montgomery Twp	Bel Baltzer Enterprises	Jun 1983	255	70	6	50	Unscreened	205	Steel	20	NA	Loop System Heat Pump	Shale	Not Sampled
32	28-2-486	Montgomery Twp	Bel Baltzer Enterprises	Jun 1983	255	70	6	50	Unscreened	205	Steel	20	NA	Loop System Heat Pump	Shale	Not Sampled
33	28-2-486	Montgomery Twp	Bel Baltzer Enterprises	Jun 1983	398	100	6	50	Unscreened	348	Steel	25	NA	Loop System Heat Pump	Shale	Not Sampled
34	28-2-486	Montgomery Twp	Mundy-Nestler, Inc.	5 Feb 1964	86	7	6	50	Unscreened	36	Steel	37	55	Domestic	Sandstone	Not Sampled
35	28-2-486	Montgomery Twp	Mundy-Nestler, Inc.	27 Sept 1963	152	7	6	50	Unscreened	102	Steel	45	75	Domestic	Shale	Not Sampled
36	28-2-486	Montgomery Twp	George Sands	6 Nov 1961	130	40	6	32	Unscreened	98	Steel	20	55	Domestic	Red Shale	Not Sampled
37	28-2-486	Montgomery Twp	Charles Egner	14 May 1962	249	6	6	34	Unscreened	215	Steel	24	80	Domestic	Red Shale	Not Sampled
38	28-2-487	Montgomery Twp	Walter Stanski	25 May 1956	121	10	6	46	Unscreened	75	Steel	32	41	Domestic	Shale	Not Sampled
39	28-2-487	Montgomery Twp	All-Star Builders	22 Jul 1963	137	15	6	40	Unscreened	97	Steel	50	90	Domestic	Shale	Not Sampled
40	28-2-487	Rt. 518, Montgomery Twp	Charles Perpetua	30 Jun 1963	120	20	6	51	Unscreened	69	Steel	50	80	Domestic	Shale	Not Sampled
41	28-2-487	Montgomery Twp	James T. Collins	30 Oct 1953	100	6	6	34	Unscreened	66	Steel	25	60	Domestic	Red Shale	Not Sampled
42	28-2-489	NA	Longridge Builders, Inc.	6 May 1963	278	62	10	42	Unscreened	236	Steel	28	160	NA	Red Shale	Not Sampled
43	28-2-489	Montgomery Twp	George Sands	16 Nov 1961	130	50	6	30	Unscreened	100	Steel	35	100	Domestic	Red Shale	Not Sampled
44	28-2-491	Montgomery Twp	Charles Egner	30 Nov 1962	138	10	6	34	Unscreened	104	Steel	30	75	Domestic	Red Shale	Not Sampled
45	28-2-491	Montgomery Twp	Charles Egner	20 Nov 1962	150	10	6	46	Unscreened	104	Steel	32	70	Domestic	Red Shale	Not Sampled
46	28-2-491	Montgomery Twp	Henry Young	20 Sept 1954	189	10	6	22	Unscreened	167	Steel	25	140	Domestic	Red Shale	Not Sampled
47	28-2-494	Montgomery Twp	Charles Egner	28 Apr 1964	156	7	6	50	Unscreened	106	Steel	64	80	Domestic	Red Shale	Not Sampled
48	28-2-494	Montgomery Twp	Charles Egner	25 Apr 1963	122	10	6	50	Unscreened	72	Steel	42	50	Domestic	Red Shale	Not Sampled
49	28-2-494	Montgomery Twp	Charles Egner	30 Jan 1963	140	10	6	50	Unscreened	90	Steel	25	70	Domestic	Red Shale	Not Sampled
50	28-2-494	Montgomery Twp	Charles Egner	13 Nov 1962	179	10	6	47	Unscreened	132	Steel	20	60	Domestic	Red Shale	Not Sampled
51	28-2-494	Montgomery Twp	Mundy-Nestler, Inc.	22 May 1963	113	7	6	50	Unscreened	63	Steel	58	75	Domestic	Shale	Not Sampled
52	28-2-494	Montgomery Twp	Charles Egner	21 Sept 1962	149	15	6	34	Unscreened	115	Steel	22	50	Domestic	Red Shale	Not Sampled

TABLE 3-1, CONTINUED

Ref. No.	New Jersey Coordinate System Location No.	Reported Address	Original Owner	Date Drilled	Total Depth (ft)	Reported Yield (gpm)	Well Diameter (in)	Length of Casing Installed (ft)	Depth of Interval Screened (ft)	Length of Open, Uncased Section (ft)	Casing and Screen Material	Depth to Static Water on Date Drilled (ft)	Depth to Pumping Water Level (ft)	Use	Aquifer	Analyses of Well Water
53	28-2-494	Montgomery Twp	Mundy-Nestler, Inc.	21 May 1963	115	7	6	50	Unscreened	65	Steel	42	75	Domestic	Shale	Not Sampled
54	28-2-494	Montgomery Twp	Mundy-Nestler, Inc.	23 May 1963	147	5	6	50	Unscreened	97	Steel	48	75	Domestic	Shale	Not Sampled
55	28-2-494	Montgomery Twp	Charles Egner	12 Apr 1962	235	8	6	24	Unscreened	211	Steel	32	160	Domestic	Red Shale	Not Sampled
56	28-2-495	Cleveland Circle, Montgomery Twp	Fisher-Ancona Builders, Inc.	21 Jun 1966	123	20	6	52	Unscreened	71	Steel	30	100	Domestic	Red Shale	Not Sampled
57	28-2-495	Cleveland Circle, Montgomery Twp	Fisher-Ancona Builders, Inc.	30 Nov 1967	193	50	6	50	Unscreened	143	Steel	20	150	Domestic	Shale	Not Sampled
58	28-2-495	Montgomery Twp	Charles Egner	9 May 1962	100	7	6	23	Unscreened	77	Steel	16	70	Domestic	Red Shale	Not Sampled
59	28-2-495	Montgomery Twp	Charles Egner	28 Aug 1961	166	3	6	22	Unscreened	144	Steel	30	140	Domestic	Red Shale	Not Sampled
60	28-2-498	Montgomery Twp	Rock-Hill Realty Co.	14 Mar 1962	500	205	10	40	Unscreened	460	Steel	0	118	Test Well	Red Shale	Not Sampled
61	28-2-499	Montgomery Twp	Charles Egner	26 Sept 1961	150	4	6	23	Unscreened	127	Steel	25	90	Domestic	Red Shale	Not Sampled
62	28-2-546	Canal Road, Franklin Twp	Gordon Gund	3 Sept 1983	450	6	6	100	Unscreened	350	Steel	40	410	Domestic	Diabase	Not Sampled
63	28-2-548	Canal Road, Franklin Twp	Charlie Melvin	1 Dec 1954	68	30	6	30	Unscreened	38	Steel	8	15	Domestic	Shale	Not Sampled
64	28-2-548	Canal Road, Franklin Twp	Gordon Spencer	10 Aug 1975	200	40	6	53	Unscreened	147	Steel	5	160	Domestic	Red Shale	Not Sampled
65	28-2-549	Montgomery Twp	Fox-Hollow Construction Co.	10 Jan 1964	137	9	6	30	Unscreened	107	Steel	55	75	Domestic	Shale	Not Sampled
66	28-2-571	Canal Road, Franklin Twp	John C. Bullitt	28 Dec 1982	225	20	6	60	Unscreened	165	Steel	NA	NA	Irrigation	NA	Not Sampled
67	28-2-571	Franklin Twp	Charles Cherris	6 Sept 1963	90	10	6	35	Unscreened	55	Steel	15	60	Domestic	Bedrock	Not Sampled
68	28-2-578	Franklin Twp	Louis Lipot	19 Jun 1954	95	10	6	24	Unscreened	71	Steel	20	30	Domestic	Bedrock	Not Sampled
69	28-2-578	NA	Harold Burdett	18 Aug 1953	115	10	6	20	Unscreened	95	Steel	28	55	Domestic	Shale	Not Sampled
70	28-2-7	Old Hercules Powder Plant, Rocky Hill Boro	NJDEP, Water Resources	11 Feb 1983	75	6	4	21	Unscreened	54	Steel	74	NA	Monitor Well	Red Shale	NA
71	28-2-7	Old Hercules Powder Plant, Rocky Hill Boro	NJDEP, Water Resources	11 Feb 1983	75	NA	4	21	Unscreened	54	Steel	NA	NA	Monitor Well	Red Shale	NA
72	28-2-7	Franklin Twp	C. Smith	10 Aug 1970	190	15	6	50	Unscreened	140	Steel	120	25	Domestic	Shale	Not Sampled
73	28-2-71	Princeton Airport	Teterboro Aircraft Service, Inc.	10 Jun 1983	10	NA	2	10	5 to 10	0	PVC	NA	2	Monitor Well	Red Siltstone	NA
74	28-2-71	Princeton Airport	Teterboro Aircraft Service, Inc.	14 Jun 1983	15	NA	2	15	10 to 15	0	PVC	NA	6	Monitor Well	Red Siltstone	NA
75	28-2-71	Princeton Airport	Teterboro Aircraft Service, Inc.	9 Jun 1983	15	NA	2	15	10 to 15	0	PVC	NA	2	Monitor Well	Red Siltstone	NA
76	28-2-71	Princeton Airport	Teterboro Aircraft Service, Inc.	NA	NA	NA	2.5	24	Unscreened	NA	Steel	NA	NA	Monitor Well	Red Silstone	NA

E638/255

MTH 001 0642

TABLE 3-1, CONCLUDED

Ref. No.	New Jersey Coordinate System Location No.	Reported Address	Original Owner	Date Drilled	Total Depth (ft)	Reported Yield (gpm)	Well Diameter (in)	Length of Casing Installed (ft)	Depth of Interval Screened (ft)	Length of Open, Uncased Section (ft)	Casing and Screen Material	Depth to Static Water on Date Drilled (ft)	Depth to Pumping Water Level (ft)	Use	Aquifer	Analyses of Well Water
77	28-2-717	Montgomery Twp	Brookside Associates	9 May 1977	140	50	6	41	Unscreened	99	Steel	130	10	Domestic	Bluish-Grey Shale	NA
78	28-2-722	Montgomery Twp	George Sands	28 May 1961	134	40	6	34	Unscreened	100	Steel	100	32	Domestic	Red Shale	Not Sampled
79	28-2-724	Montgomery Twp	Walter D. Waters	31 Dec 1955	99	8	6	22	Unscreened	77	Steel	65	12	Domestic	Red Shale	Not Sampled
80	28-2-724	Montgomery Twp	Carter Inc.	10 Aug 1964	150	50	6	32	Unscreened	118	Steel	100	30	Domestic	Red Shale	Not Sampled
81	28-2-724	Montgomery Twp	Calvin J. Calbreth	5 Feb 1974	96	8	6	25	Unscreened	71	Steel	70	16	Domestic	Red Shale	Not Sampled
82	28-2-724	Montgomery Twp	M.L. Dodge, Inc.	28 May 1963	200	40	6	41	Unscreened	159	Steel	100	25	Domestic	Bluish-Grey Shale	Not Sampled
83	28-2-725	Montgomery Twp	Kammler Bulc	16 Apr 1960	95	20	6	33	Unscreened	62	Steel	50	8	Domestic	Bluish-Grey Shale	Not Sampled
84	28-2-725	Montgomery Twp	Francis A. Tash	10 Oct 1954	94	15	6	22	Unscreened	72	Steel	30	8	Domestic	Red Shale	Not Sampled
85	28-2-727	Montgomery Twp	Brookside Associates	13 May 1977	160	60	6	43	Unscreened	117	Steel	100	5	Domestic	Bluish-Grey Shale	Not Sampled
86	28-2-727	Montgomery Twp	Jeannett F. Wilson	1952	88	5	6	25	Unscreened	63	Steel	70	10	Domestic	NA	Not Sampled
87	28-2-727	Montgomery Twp	Emanual Kennidy	27 Sept 1954	105	5	6	20	Unscreened	85	Steel	70	18	Domestic	Red Shale	Not Sampled
88	28-2-727	Princeton Twp	Atlantic Refining Co.	22 Feb 1962	NA	7	6	20	Unscreened	NA	Steel	90	15	Gas Station	Bluish-Grey Shale	Not Sampled
89	28-2-727	Montgomery Twp	Emanuel Kennidy	27 Sept 1954	105	5	6	22	Unscreened	83	Steel	70	18	Domestic	Red Shale	Not Sampled
90	28-2-732	Rocky Hill	Ameliotex, Inc.	1 Nov 1971	310	40	8	30	Unscreened	280	Steel	252	10	Test Well	Red Shale	Not Sampled
91	28-2-732	Rocky Hill	Young Dev-Lab, Inc.	22 May 1957	107	10	6	21	Unscreened	86	Steel	80	15	Industrial	Blue Shale	Not Sampled
92	28-2-733	Montgomery Twp	Fisher-Ancona Builders, Inc.	29 Apr 1965	118	25	6	53	Unscreened	65	Steel	100	20	Domestic	Red Shale	Not Sampled
93	28-2-734	Montgomery Twp	Roy Krupa	9 Oct 1978	165	15	6	50	Unscreened	115	Steel	120	40	Domestic	Shale	Not Sampled
94	28-2-734	Montgomery Twp	Daniel Johnson	27 Jun 1958	90	2.5	6	22	Unscreened	68	Steel	70	18	Domestic	Blue Shale	Not Sampled
95	28-2-735	Montgomery Twp	Fred E. Cruser	16 Nov 1953	76	11	6	22	Unscreened	54	Steel	50	18	Domestic	Blue Shale	Not Sampled
96	28-2-735	Montgomery Twp	Fisher-Ancona Builders, Inc.	10 Apr 1968	118	30	6	50	Unscreened	68	Steel	100	20	Domestic	Shale	Not Sampled
97	28-2-735	Montgomery Twp	Fred E. Cruser	16 Nov 1953	76	11	6	22	Unscreened	54	Steel	50	18	Domestic	Blue Shale	Not Sampled
98	28-2-879	West Windsor	Joseph Hoffman	25 Apr 1968	65	25	4	60	60 to 65	5	PVC	37	20	Domestic	NA	Not Sampled

Eliminate

TABLE 3-2
SUMMARY OF WELL DEPTHS AND GROUND-WATER QUALITY DATA

Well Location	Type of well	Depth of well (feet)	Ground-water quality data
Wells at Potential Sources Sites			
Ingersoll Rand	Water Supply	506	TCE: 14 ppb
Princeton Chemical Research	Water Supply	300	TCE: 125 to 402 ppb PCB: 56ppb; 16 peaks on GC
Polycell	Water Supply	150	TCE: 98 ppb PCB: trace
Texaco Gas Station	Water Supply	unknown	TCE: 3ppb
Thul's Auto and Mobil	Water Supply	unknown	TCE: 120 ppb
Princeton Gamma Tech	Water Supply	unknown	TCE: 9 ppb
Wm Penn Gas	Water Supply	unknown	TCE: 9 ppb
Compo Industries	Water Supply	310(?)	TCE: 37 ppb; Seven Volatile Organics 50 ppb.
Princeton Airport	Sampling trench		Toluene: 18,000 ppb Benzene: 8,000 ppb 19 Volatile Organic peaks

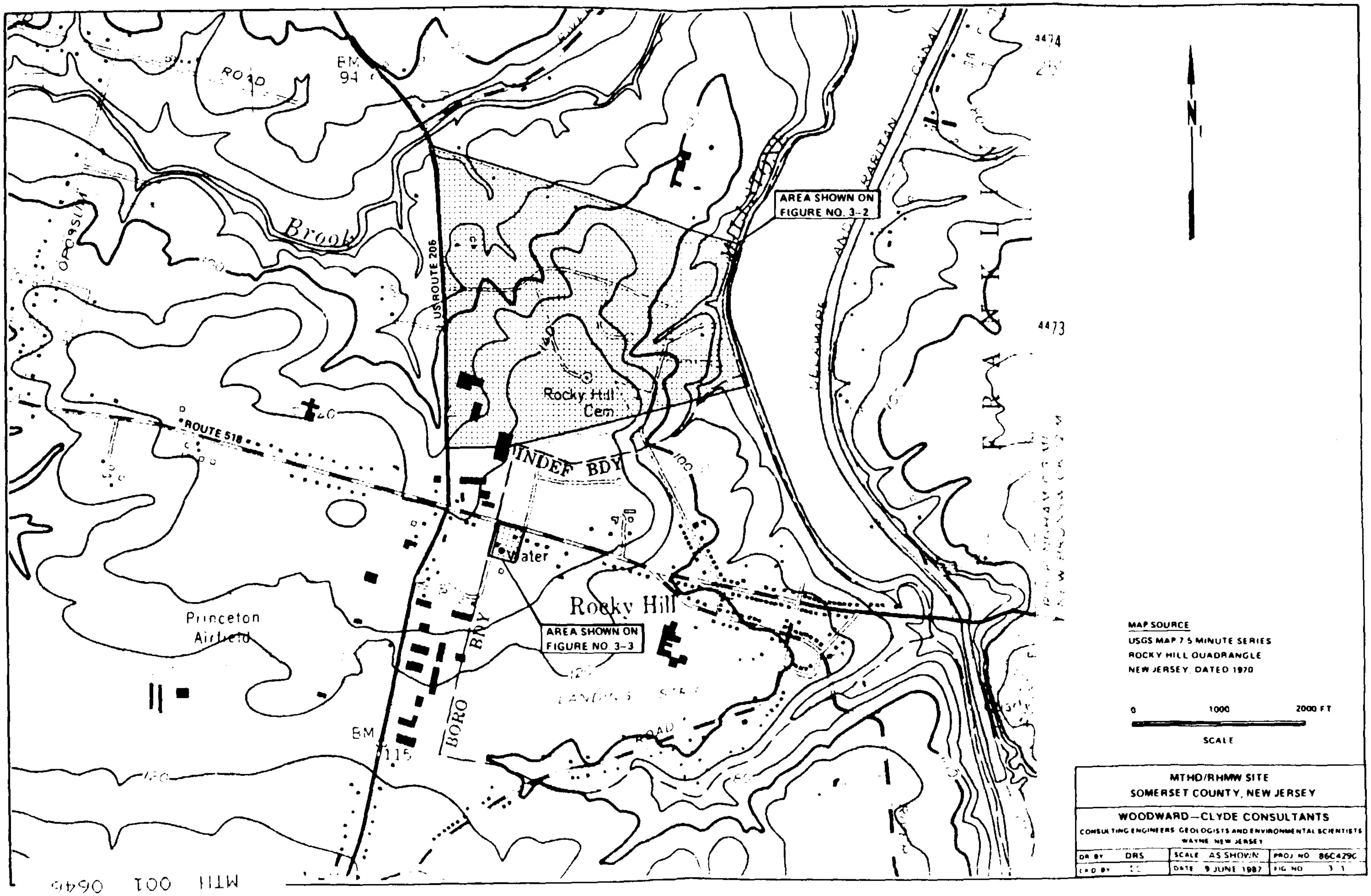
RB87-133t2

TABLE 3-2 (Continued)
SUMMARY OF WELL DEPTHS AND GROUND-WATER QUALITY DATA

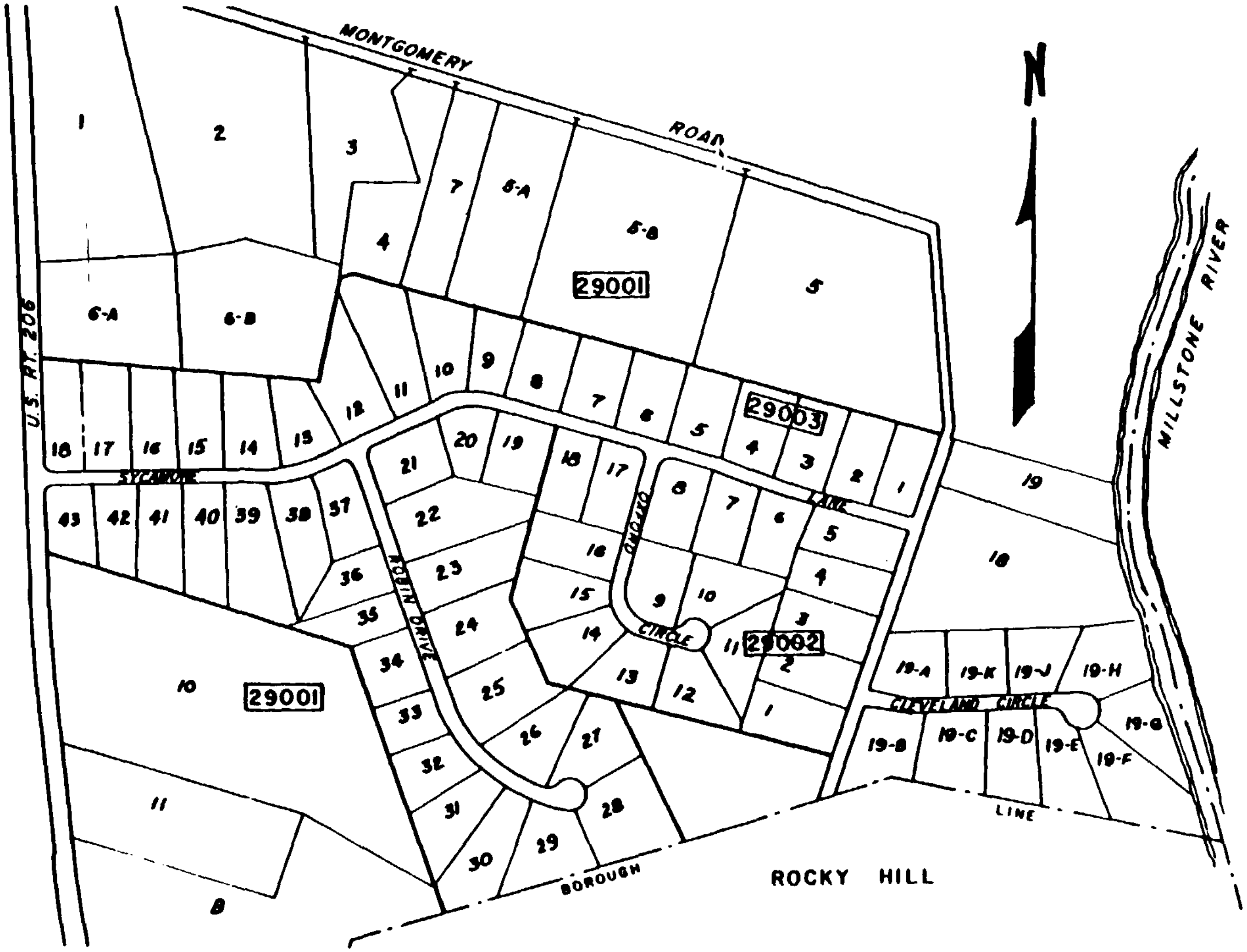
Well Location	Type of well	Depth of well (feet)	Ground-water quality data
Compo Industries	NJDEP Monitoring Well	78	1,1,1-Trichloroethane: 3 ppb
Village Shopper	NJDEP Monitoring Well	78	none detected

Wells at MTHD/RHMW

RHMW #2	Water Supply	278	TCE: 365 ppb (Well in operation, water is treated).
MTHD Robin Drive	Water Supply	125 (avg)	TCE: 950 ppb
MTHD Oxford Circle	Water Supply	125 (avg)	TCE: 340 ppb
MTHD Cleveland Circle	Water Supply	125 (avg)	TCE: 318 ppb

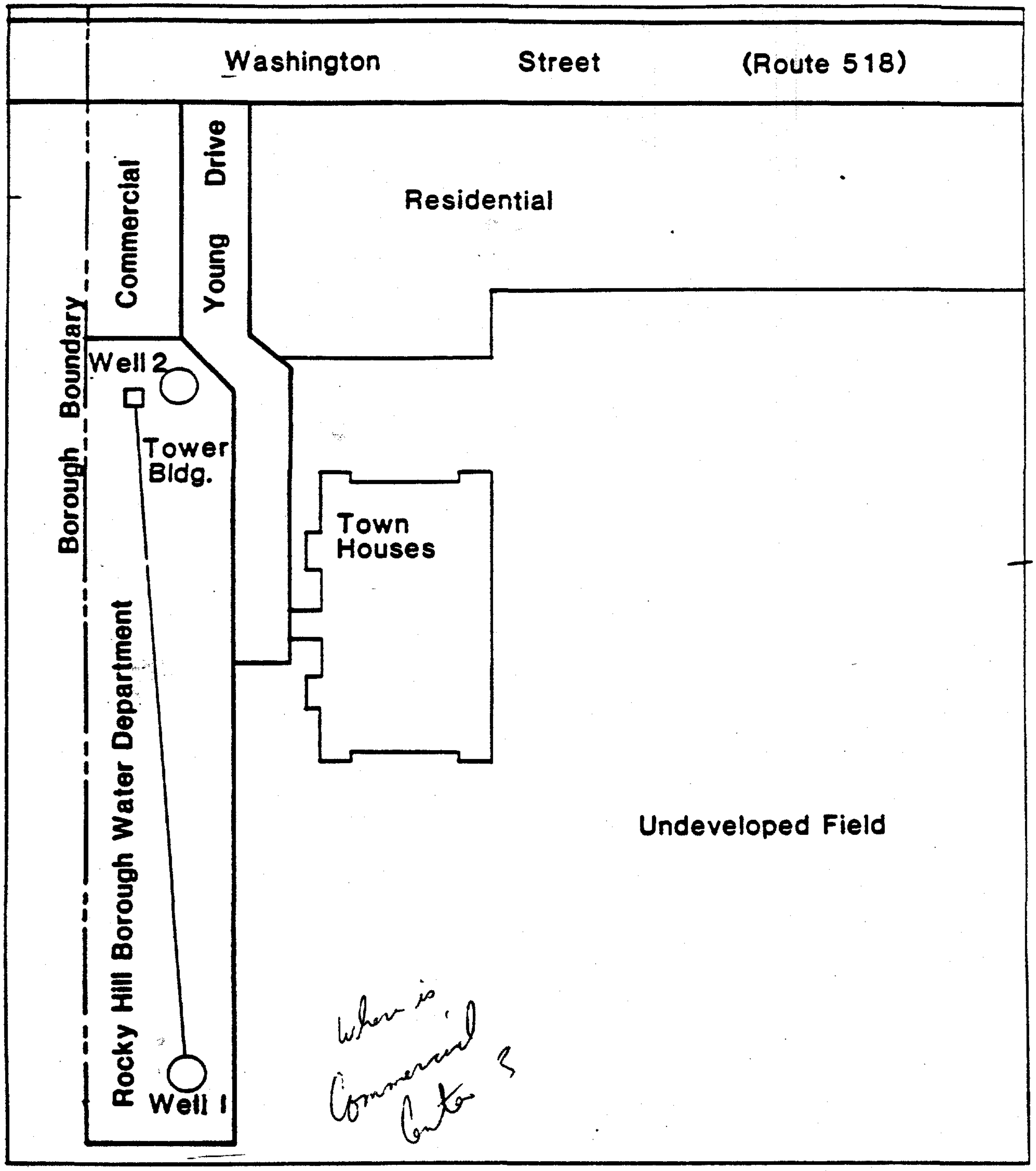


AREA SHOWN ON FIGURE NO. 3-2
AREA SHOWN ON FIGURE NO. 3-3
US ROUTE 206
ROUTE 518
Brook
Rocky Hill Cem.
INDEF BDY
Water
Rocky Hill
Princeton Airfield
BORO BDY
ROAD
CANAL
N
MAP SOURCE
USGS MAP 7.5 MINUTE SERIES
ROCKY HILL QUADRANGLE
NEW JERSEY, DATED 1970
0 1000 2000 FT
SCALE
MTHD/RHMW SITE
SOMERSET COUNTY, NEW JERSEY
WOODWARD—CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY
DR BY DRS
SCALE AS SHOWN
PROJ NO 86C429C
DATE 9 JUNE 1987



SOURCE:
MONTGOMERY TOWNSHIP TAX MAP,
1984 RAMP BY JACA AND NUS

MONTGOMERY TOWNSHIP HOUSING DEVELOPMENT MONTGOMERY TOWNSHIP, NEW JERSEY					
WOODWARD – CLYDE CONSULTANTS CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS WAYNE, NEW JERSEY					
DR BY	DRS	SCALE	1" = 570'	PROJ NO	86C4290
CK'D BY	EC	DATE	9 JUNE 1987	FIG NO	3–2



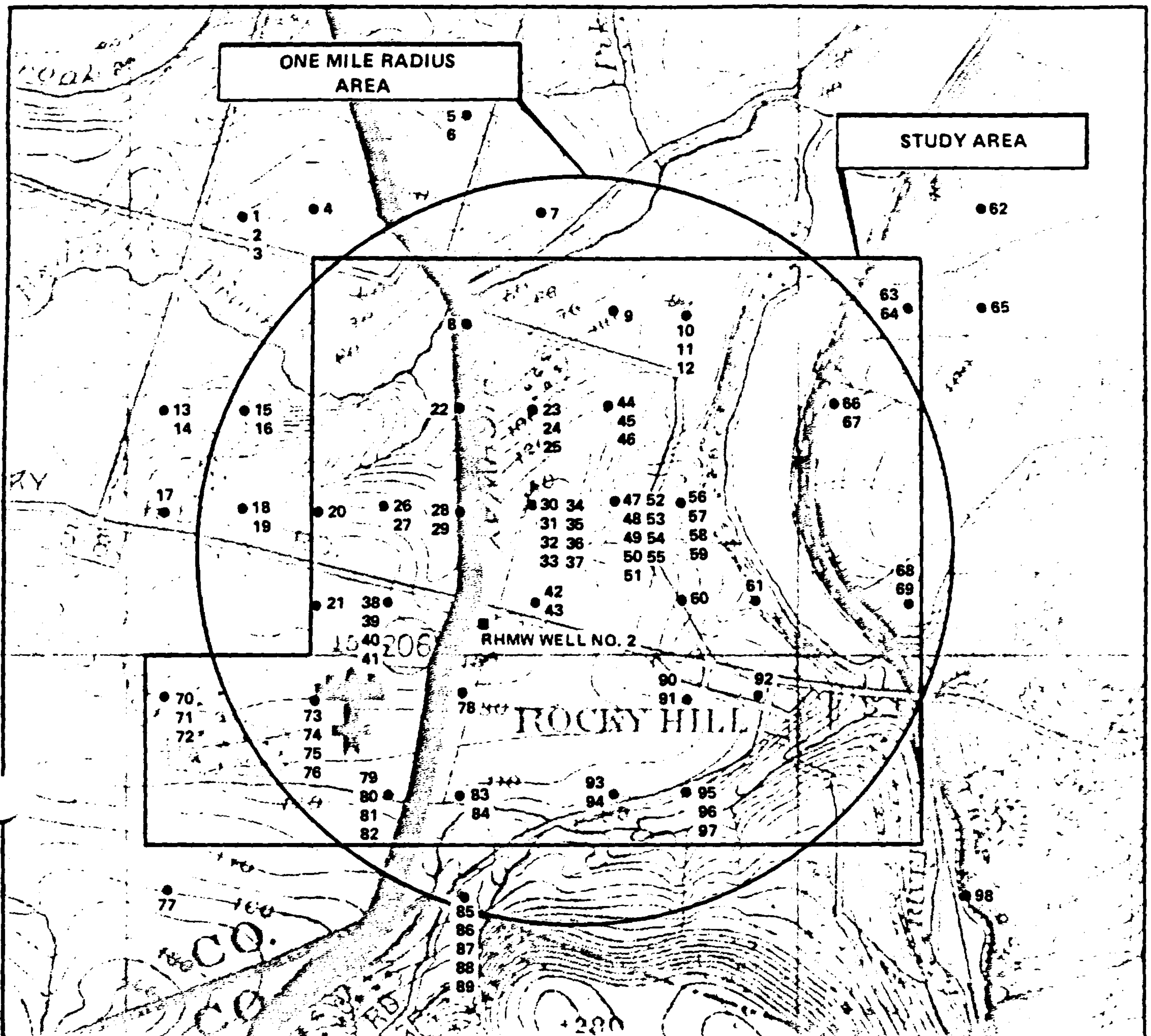
SOURCE:
1984 RAMP BY
JACA AND NUS

SITE LOCATION MAP
ROCKY HILL MUNICIPAL WELLFIELD
ROCKY HILL, NEW JERSEY

WOODWARD - CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR. BY:	DRS	SCALE:	NTS	PROJ. NO.:	86C4290
CK'D BY:	EC	DATE:	9 JUNE 1987	FIG. NO.:	3-3

MTH 001 0648



LEGEND

25 WELL NUMBER CORRESPONDS TO TABLE 3–1

● LOCATION OF WATER WELL, FROM NJDEP RECORDS

0 2100 4200 FT

SCALE

MAP SOURCE:

NJDEP, TOPOGRAPHIC SHEET NO. 28
TRENTON, NEW JERSEY. PHOTOREVISED 1957

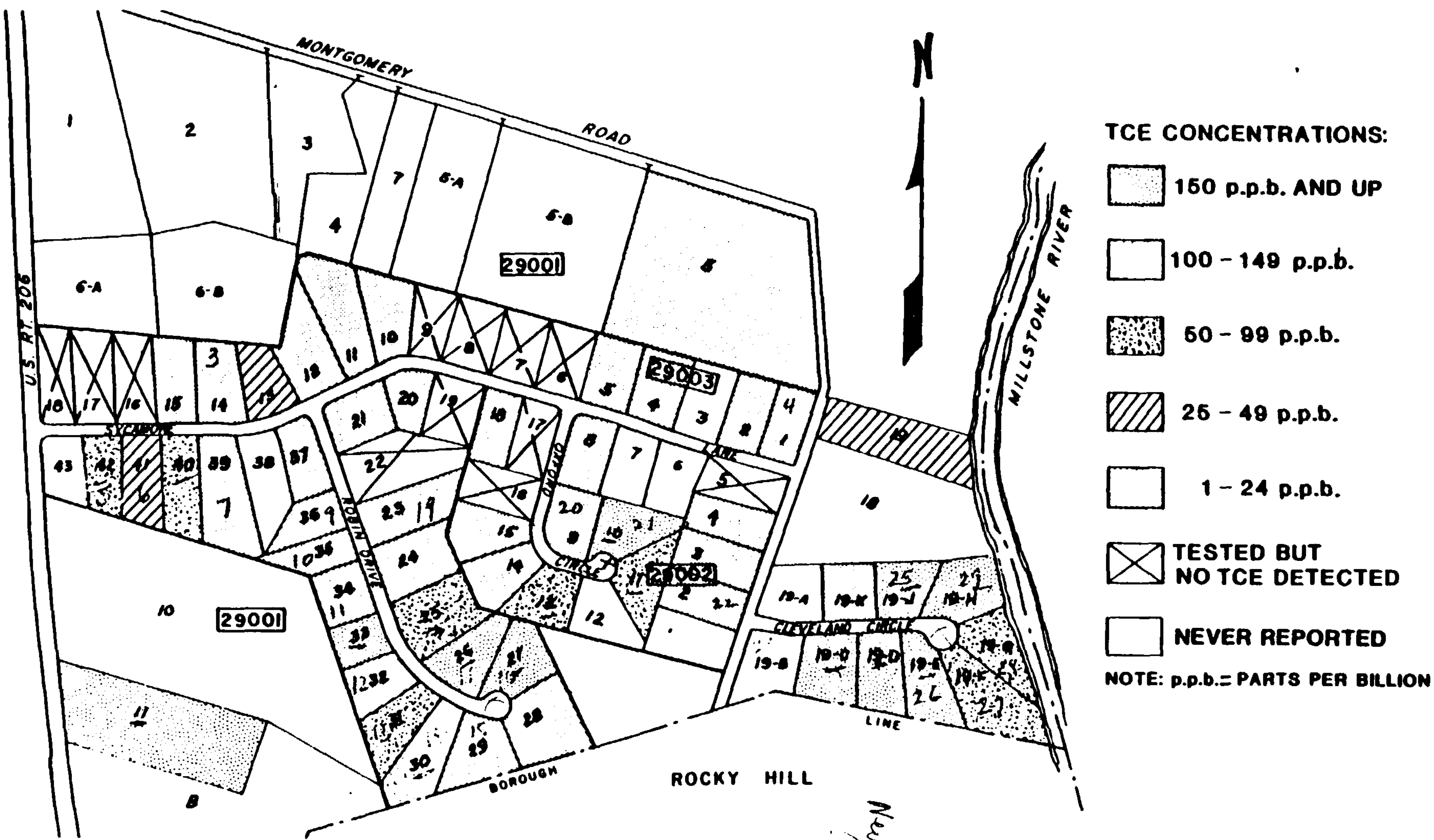
APPROXIMATE LOCATIONS OF EXISTING WATER WELLS
MTHD/RHMW SITE
SOMERSET COUNTY, NEW JERSEY

WOODWARD—CLYDE CONSULTANTS

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTIS
WAYNE, NEW JERSEY

DR. BY:	DRS	SCALE:	AS SHOWN	PROJ. NO.:	86C4290
CK'D. BY:	GW	DATE:	9 JUNE 1987	FIG. NO.:	3–4

MTH 001 0649



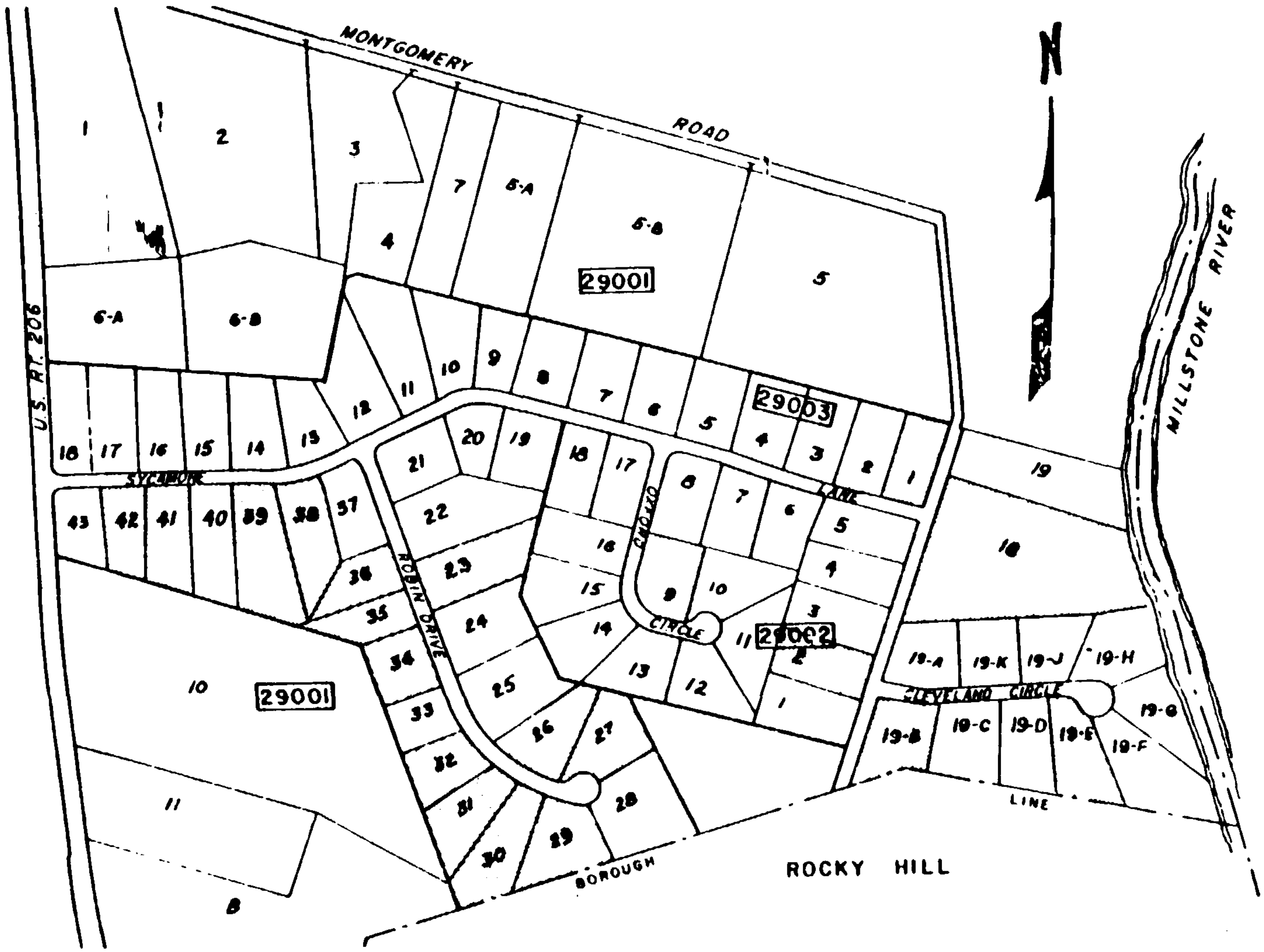
SOURCE:
SEARFOSS, 7/22/83,
1984 RAMP BY JACA AND NUS

TCE CONCENTRATIONS
MONTGOMERY TOWNSHIP HOUSING DEVELOPMENT
MONTGOMERY TOWNSHIP, NEW JERSEY

WOODWARD - CLYDE CONSULTANTS

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR BY	DRS	SCALE	1" = 570'	PROJ NO	86C4290
CK'D BY	EC	DATE	9 JUNE 1987	FIG NO	3-5



SOURCE:
SEARFOSS, 7/22/83,
1984 RAMP BY JACA AND NUS

Delete
Lot to BL
List Residences
to Present

RESIDENTS CONNECTED TO PUBLIC WATER AS OF APRIL 1984 MONTGOMERY TOWNSHIP HOUSING DEVELOPMENT MONTGOMERY TOWNSHIP, NEW JERSEY					
WOODWARD - CLYDE CONSULTANTS CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS WAYNE, NEW JERSEY					
DR BY	DRS	SCALE	1" = 570'	PROJ NO	86C4290
CK'D BY	EC	DATE	9 JUNE 1987	FIG NO	3-6

SECTION FOUR
INVESTIGATIVE METHODOLOGIES

4.1 SITE RECONNAISSANCE

A preliminary site investigation was conducted by WCC during September, 1985. At this time, specific locations for the electrical resistivity survey were chosen, and the accessibility of the proposed monitoring well locations to drilling rigs was assessed. Further reconnaissance was done with the aid of aerial photographs. Three sets of photographs were used dated 1 October through 5 October, 1956, 12 October, 1971 and 13 March through 20 March, 1979. These photographs were used to identify any additional information on the potential sources of contamination and, subsequently, to locate strategically the monitoring wells.

4.2 LEVELING SURVEY

A topographic and cultural feature map of the site and the adjacent Rocky Hill Municipal Wellfield site was prepared by Lau and Shabunia in June, 1986. Elevations were surveyed to an accuracy of 0.01 foot and were referenced to a USGS bench mark. Once the monitoring wells were installed they were subjected to a horizontal and vertical-control survey. Vertical survey data are included on boring logs (Appendix D) and monitoring well installation reports (Appendix E). Horizontal survey data was used to position well locations onto the base map. The completed map is included as Plate 4-1 of the report.

4.3 SOIL AND ROCK INVESTIGATION

4.3.1 Geophysical Survey

The geophysical investigation performed at the site consisted of resistivity profiling and resistivity sounding methods of subsurface investigation. A general description of the theoretical considerations and field applications of this survey are given in Interim Report - Background Investigation for the MTHD/RHMW Site (WCC, March 1986). The primary objective of the geophysical investigation was to investigate the presence and orientation of highly fractured zones which could act as significant water-bearing conduits. The areas studied are as follows:

- between Montgomery Road and the Millstone River (Line #1)
- between Montgomery Road and Pike Run (Line #2)
- between Cherry Hill Road and Princeton Airport (Line #3)
- area bordered by Route 206 and Robin Drive

These areas were chosen based on findings from the lineament study. Resistivity profiles (lines) were run perpendicular to lineaments.

4.3.2 Lineament Analysis

Lineaments were identified on 18 aerial photographs centered on the town of Rocky Hill and encompassing a 1-mile radius which includes the Montgomery Township Housing Development. The purpose of this study was to identify surface expressions of underlying bedrock features such as fractures, bedding planes, joints, etc., which might be influencing ground water flow patterns in the site area. Specific details on the methodology employed in this study are contained in the Interim Report - Background Investigation for the MTHD/RHMW Site.

4.3.3 Monitoring Well Borings

Borings made for the purpose of installing monitoring wells were logged by WCC field inspectors. Boring logs are included in Appendix D. Information recorded on boring logs was used to interpolate subsurface conditions at the site.

4.4 GROUND WATER INVESTIGATION

4.4.1 Construction of New Monitoring Wells

Twenty-six monitoring wells were installed in the site area. Locations of wells are shown in Figure 4-1. Two types of wells were installed. Shallow wells were intended to monitor ground water in the weathered portion of the bedrock. These wells are 4.0 in. in diameter and are screened. Deep wells were intended to monitor ground water in the competent bedrock at greater depths. With the exception of well MW-3D, deep monitoring wells are 6.0 in. in diameter, and are open-hole wells. Monitoring well MW-3D has a different construction; the upper section of this well is cased and its intake section is screened.

Well installation reports are included in Appendix E of this report. All monitoring wells were installed in accordance with procedures described in Section 5.0 of Appendix A of the Quality Assurance Project Management Plan for this site. All of the deep wells were developed by air lifting. Shallow wells were developed initially by air lifting followed at a later date by water jetting. Rocky Hill Municipal Well water was used for all well installation operations.

4.4.2 Aquifer Testing

In order to characterize the aquifer beneath the site three testing methods were employed: water level surveys, permeability tests and a pump test. Water levels in monitoring wells were measured on several occasions to determine the potentiometric surface of the aquifer and to record seasonal variations. A 6-hour pump test was conducted using the Rocky Hill Municipal Well as the pumping well. Drawdown from pumping was observed in the surrounding new monitoring wells. Pumping in the municipal well was discontinued 14 hours before the pump test started so that the water could recover to its static level. During pumping, simultaneous water level measurements were made. Complete details of the pump test methodology can be found in the Summary Report - Rocky Hill Municipal Wellfield Pump Test Results for the MTHD/RHMW Site (WCC, March 1987).

Field permeability slug tests were conducted to estimate the hydraulic conductivity (permeability) of the soil/rock strata within the screened interval of each well. The test consisted of measuring the rate at which the water level rose in a monitoring well after a certain volume or 'slug' of water was suddenly removed from the well (rising head tests). Since the volume of water removed from each well is very small compared to the volume of water in the surrounding aquifer, the slug test is an estimate of permeability within only a few foot radius of the well intake. The data also tend to mask changes in the vertical distribution of the permeability by yielding one average value over the entire saturated length of the well screen.

Essentially instantaneous lowering of the water level was achieved by lowering a stainless steel submersible pump several feet below the initial water level, letting the water level reach equilibrium, and then pumping water quickly from the well. When the water level was lowered to pumping level (i.e., when the discharge of water from the hose ceased) the pump was stopped and removed. To minimize the vertical component of flow to the well, less than 5 percent of the initial water volume was removed.

A submersible pressure transducer and an electronic recording device was used to record continuously water level changes versus time.

4.4.3 Ground Water Sampling

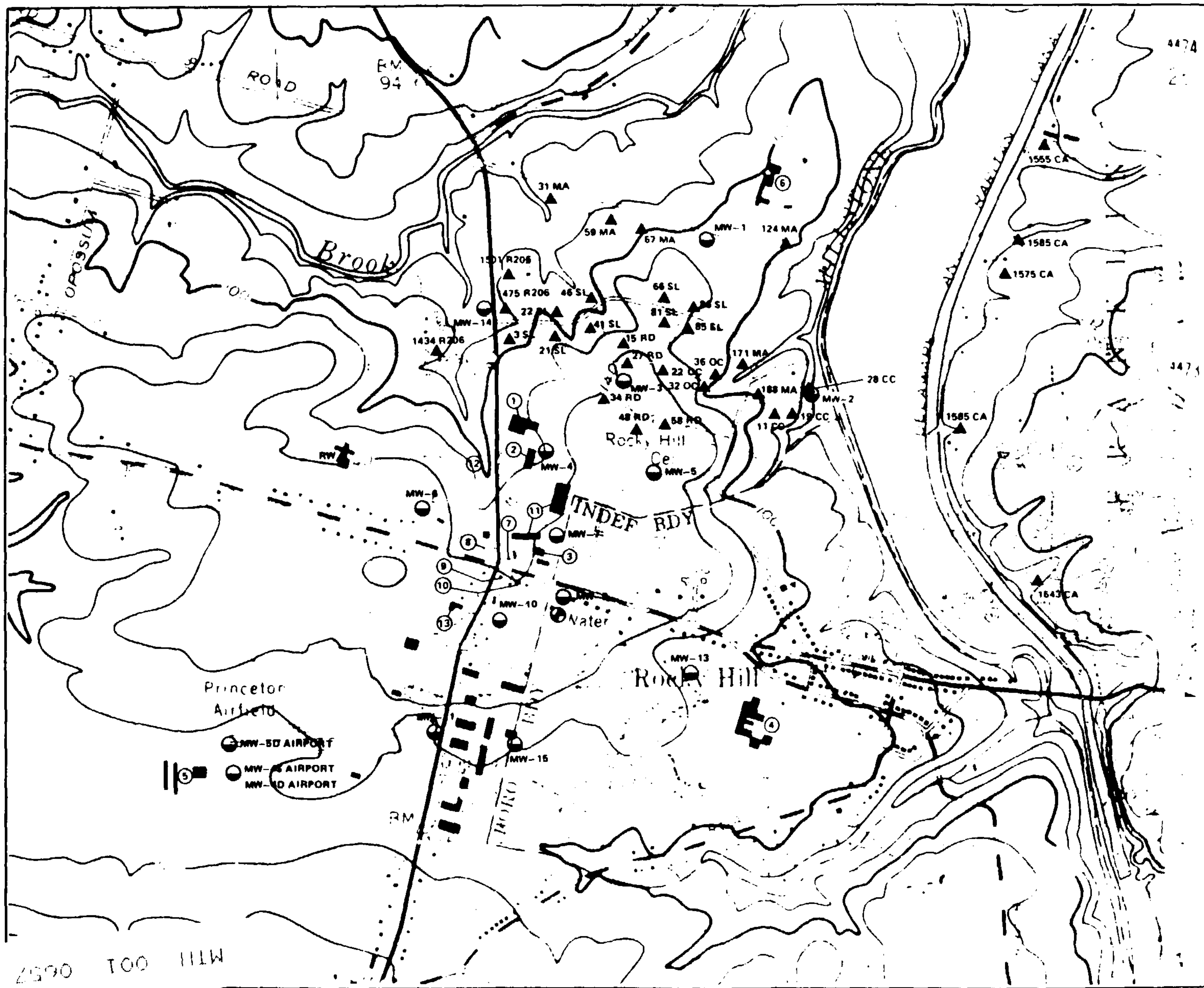
Twenty-three monitoring wells were sampled in late November and early December 1986. All but three were new wells installed by WCC. Three wells which had been installed by WCC were dry at the time of sampling and were, therefore, not sampled.

Each of the wells was purged of three well volumes no more than 2 hours prior to sampling (or pumped dry). Purging was done with either a submersible or centrifugal pump depending on the depth to water level.

Samples were collected using dedicated stainless steel bailers with either teflon or stainless steel leaders attached. Prior to use each bailer was laboratory cleaned and wrapped. Sampling procedures were conducted in accordance with those outlined in Section 7.3 in Appendix A of the Quality Assurance Project Management Plan for the site.

4.4.4 Domestic Well Sampling

On the fifth and sixth of June 1986, 35 domestic wells were sampled in and around the Montgomery Township Housing Development. The selection of wells was based on their proximity to previously identified areas of contamination. Locations of the domestic wells are included in Figure 4-1. Prior to sampling, each of the wells was evacuated until the pH, temperature and conductivity of the water was stable. This corresponded to an average evacuation time of approximately 30 minutes. All of the wells were sampled from outdoor taps which protrude from the building foundations. Water treatment devices were shut off prior to evacuation. Sampling procedures were in accordance with those outlined in Section 7.2 in Appendix A of the Quality Assurance Project Management Plan for this ~~site.~~



N

LEGEND

MW-5 — MONITORING WELL AND NUMBER

86SL — PRIVATE DOMESTIC WELL AND ADDRESS

ROCKY HILL MUNICIPAL WELL

POTENTIAL SOURCES OF CONTAMINATION (CIRCLED NUMBERS)

1. PRINCETON CHEMICAL RESEARCH
2. POLYCELL
3. PRINCETON GAMMA TECH
4. COMPO INDUSTRIES
5. PRINCETON AIRPORT
6. INGERSOLL RAND
7. THULS MOBIL GAS STATION
8. TEXACO GAS STATION
9. WM. PENN GAS STATION
10. T&C ANIMAL HOSPITAL
11. MONTGOMERY SHOPPING CENTER
12. VILLAGE SHOPPER
13. PRINCETON VOLKSWAGEN

NOTES

1. SHALLOW MONITORING WELLS DESIGNATED BY SUFFIX "S". DEEP MONITORING WELLS DESIGNATED BY SUFFIX "D". MONITORING WELLS SHOWN WITHOUT PREFIXES ARE PAIRED SHALLOW AND DEEP WELLS.
2. STREET ADDRESSES OF DOMESTIC WELLS ARE ABBREVIATED AS FOLLOWS:

CA : CANAL ROAD
CC : CLEVELAND CIRCLE
MA : MOUNTGOMERY AVENUE
OC : OXFORD CIRCLE
RD : ROBIN DRIVE
RW : RESEARCH WAY
R206 : ROUTE 206
SL : SYCAMORE LANE

SOURCE

USGS 7.5 MIN ROCKY HILL NEW JERSEY QUADRANGLE 1970

0 1000 2000 FT
SCALE

LOCATIONS OF DOMESTIC AND MONITORING WELLS MTHD/RHMW

WOODWARD—CLYDE CONSULTANTS
CONSULTING ENGINEERS GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE NEW JERSEY

DR BY	RTL	SCALE	AS SHOWN	PROJ NO	86C4290
CKD BY	EC	DATE	27 MAY 1987	FIG NO	4 1

MTH 001 0657

SECTION FIVE
DATA PRESENTATION AND ANALYSIS

5.1 SOIL AND ROCK INVESTIGATION

5.1.1 Geophysical Survey Results

Details on the collection of data from the geophysical survey conducted at the site can be found in the Interim Report-Background Investigation for the MTPD/RHMW Site ([illegible], March 19[illegible]). The results of the survey are summarized below and graphically in Appendix F. Locations for survey lines were chosen to be representative of typical site conditions. Cultural interferences close to potential sources precluded investigations in these locations.

Results of the traverse along line #1 (Figure 5-1) suggest that the lineament expressed on the surface in this area may be related to a water-saturated fracture system dipping at approximately 25 degrees towards the southwest.

Data from the traverse along line #2 (Figure 5-1) suggest a near surface zone of wetness in weathered rock and a horizontal fracture zone containing water at approximately 60 to 90 feet below the ground surface.

Results of the survey along line #3 suggest a near-vertical water saturated zone in that area.

Results of the soundings in the area between Route 206 and Robin Drive are depicted in Figure F-14 of Appendix F and as a recumbent diamond symbol in Figure 5-1. The findings suggest a water saturated vertical fracture system trending approximately 65 degrees east of north. The data also suggest a near surface water saturated horizontal fracture system.

5.1.2 Lineament Study Results

The majority of the lineaments identified fit into three groups. The largest number have trends which range in azimuth from 50 to 70 degrees. The second and third most numerous groups of lineaments trend 270 to 290 degrees and 10 to 20 degrees (Figures 5-1 and 5-2).

The latter groups were observed in the field and represent bedrock fractures with dips ranging from moderately steep to vertical. Bedding planes observed in the field strike 40 to 50 degrees. Because only four lineations were found to have similar orientations to the bedding plane, it is concluded that the lineation fabric represents bedrock fractures which are not parallel to bedding. Based on these data, the maximum transmissivity along bedrock fractures in the Brunswick aquifer should be mainly between northeast and east with lesser components towards the north-northeast (or 180 degrees from these directions depending on regional flow directions).

5.1.3 Boring Logs

The boring logs (Appendix D) indicate that most of the site is underlain by a thin veneer (generally less than 4 ft) of mainly dark reddish brown sand with varying amounts of clay, silt and gravel. This overburden rests on top of deeply weathered dark reddish brown mudstone. The mudstone's hardness and strength increases with depth below the ground surface. The thickness of the mudstone in each of the boring locations varies. Similarly, the underlying stratigraphy varies between locations. The rocks consist mainly of reddish brown siltstone, claystone and sandstone. Lesser amounts of calcareous mudstone and siltstone are also present. Thin beds (less than 10 ft) of argillaceous limestone and dolostone are present in most boring locations. An attempt to correlate stratigraphic layering between borings was not possible suggesting that these units may not be laterally continuous. Most of the rock cores contained close to moderate fracture spacing.

5.2 GROUND WATER INVESTIGATION

5.2.1 Physical Characteristics

5.2.1.1 Water Elevations. Water level measurements were used to determine ground-water flow patterns in the site area. Because of the effect of pumping of the Rocky Hill Municipal Well (RHMW) on water levels in some of the deep wells, only one set of measurements is believed to represent unimpacted natural ground water patterns in the area (see Section 5.2.1.2). These measurements were made just after RHMW had been shut off for 14 hours, allowing water levels to recover to their static conditions (Table 5-1). Measurements from shallow and deep wells under static conditions indicate that several water-bearing zones are present which are separated by less permeable (or lower fracture density) units. The deeper zones may be unconfined or semi-confined. A water-table aquifer is intercepted by the shallow wells and occurs at depths ranging from less than 3 to more than 40 ft beneath the ground surface. Ground-water elevations in shallow wells are uniformly higher than the deeper wells. Head differences between shallow and deep wells indicate a potential for downward vertical movement of water if a pathway exists. The fractures investigated by the geophysical surveys are likely to be representative of these pathways.

Contours of the piezometric surfaces based on static level measurements are shown in Figures 5-3 and 5-4. In general, the shallow, water-table zone of the aquifer flows towards the northeast but diverges along a northeast trending axis through the center of the Housing Development and flows toward the east and northwest. Shallow ground water flows from the site toward two surface water bodies: the Millstone River on the east and Beden Brook, a tributary of the Millstone, on the north. Both of these water bodies flow toward the north. Water table contours are approximately parallel to topographic contours of the site. Apparent water table gradients interpolated between monitoring wells are gentler toward the northeast and are steeper (up to 0.03) toward the east and northwest.

Water elevation contours based on measurements from the deep wells show a similar pattern to those based on shallow wells. The primary differences between the two are that the piezometric surface for the deep aquifer has a slightly steeper gradient and less well defined divide between eastward and northwest ward flow. A typical gradient reflected by the water elevations in the deep wells is 0.03.

As stated above, the conditions described represent background static levels. In order to evaluate more typical conditions, we need to consider the effects of pumping at the RHMW. On the average, the RHMW pumps for 2 to 3 hours approximately three times a day (Larry Merk, personal communication, 5 November 1986). Data obtained from the pump test performed at the RHMW after 5 hours of continuous pumping indicate that the ground water flow in the Montgomery Township Housing Development does not appear to be significantly affected by pumping at the RHMW.

Seasonal variations may be deduced by observing wells which are known to be uneffected by pumping at the RHMW (Table 5-1). These measurements indicate that the shallow and deeper zones of the aquifer show no discernible pattern of seasonal variation between the summer and winter of 1986.

5.2.1.2 Pump Test. On 13 December 1986 a short duration pumping test was performed on the Rocky Hill Municipal Well (RHMW). Pumping of the well lasted 6 hours and was subsequently followed by a recovery period. Personnel from WCC monitored the water levels in the monitoring wells during both the drawdown and recovery periods. Mr. Larry Merk, Rocky Hill's Water Supervisor, operated and monitored the pumping equipment within the well house.

The purpose of the pumping test was to: estimate the transmissivity of the bedrock aquifer; investigate whether the deeper water-bearing zones in the bedrock aquifer and the overlying shallow water-table aquifer are hydraulically directly connected; find the radius of influence of the municipal well; and gain a better understanding of the flow system being examined.

Pump test data are included in WCC's summary report of the pump test (WCC, March 1987). Effects of pumping on the ground water elevations and piezometric surface are illustrated in Figures 5-5 and 5-6. Drawdown data at each observation well were analyzed using three different methods. All wells which exhibited drawdown were subjected to a Theis type curve analysis, assuming confined, radial flow and an aquifer of infinite areal extent. The second method is the commonly used Jacob method for analyzing unsteady radial flow to a fully penetrating pumping well located in a homogeneous, isotropic aquifer of infinite horizontal extent. The third method was derived by Jenkins and Prentice (1982) for the case of linear flow toward a fully-penetrating fracture in an isotropic aquifer.

The Theis method is a nonequilibrium well function equation and takes into account the effect of pumping time on well yield. Values of drawdown versus time are plotted on log-log scale and graphically matched with the theoretical type curve of the well function W(u) versus u. u is defined as:

$$u = \frac{1.87 \quad r^2 S}{Tt}$$

where r is distance in feet (radially from the pumping center), S is the coefficient of storage (dimension less or ft/ft), T is the coefficient of transmissivity in gpd/ft and t is the time since pumping began in days. W(u) is an exponential integral derived from heat flow theory.

Because drawdown can be expressed as:

$$s = \frac{114.6 \; Q \; W(u)}{T}$$

where s is drawdown in feet and Q is discharge in gpm, we can calculate transmissivity using:

$$T = \frac{114.6\ Q\ W(u)}{s}$$

Storage coefficient can than be estimated by:

$$S = \frac{u\ T\ t}{2693\ r^2}$$

with t being time in minutes.

The Jacob method is a simplified version of the Theis method of pumping test data analysis. The method makes the assumptions listed above regarding the aquifer and well characteristics and has the further limitation that it should only be used when the well function similarity variable, u is less than 0.01.

According to theory, data with similarity variable values less than .01 should plot as a straight line when the log of time is plotted against the drawdown. The slope of this straight line can then be used to determine aquifer transmissivity. The intercept of the straight line is an indicator of the storage coefficient of the aquifer. The equations for the transmissivity and storage are:

$$T = \frac{264Q}{\Delta s}$$

$$S = \frac{Tt_o}{4790}\ r^2$$

where Q is the pumping rate (gal/min), Δs is the drawdown per log cycle of time (ft), t_e is the time at the point where the straight line intersects the zero-drawdown line (min), and r is the radial distance between the pumping well and the monitoring well (ft).

It is evident that the assumptions of the Jacob method were not all realized during the Rocky Hill pump test. However, by making semi-log plots of time vs drawdown for each observation well and noting which data sets plot as a straight line, it is possible to determine the locations where radial flow towards the pumping well appears to occur. At the locations where radial flow does occur, transmissivity can then be approximated by the standard Jacob method.

The method developed by Jenkins and Prentice (1982) is for determining hydraulic parameters of a fractured-rock aquifer. The method assumes linear flow toward a fully-penetrating fracture. The Jenkins-Prentice analysis indicates that in regions where such linear flow predominates, a data plot of drawdown against the square-root of time should yield a straight line. Conversely, it is, therefore, possible to determine where linear flow toward fractures occurs in an aquifer by plotting drawdown against the square-root of time at each observation well and finding out for which wells straight lines result. Once such straight-line plots are found, the transmissivity can be found from

$$\frac{T}{S} = \frac{\pi}{4} \frac{x^2}{t_0}$$

where x is the perpendicular distance from the fracture to the observation point.

Pumping of the RHMW well was found to affect the water levels in six of the deep monitoring wells; MW-7D, MW-9D, MW-10D, MW-11D, MW-13D and MW-15D. (MW-13D only experience a minor drawdown of .3 ft. None of the shallow wells was influenced by pumping during the 6 hours of the fest. The "radius of influence" of the pumping well extended further to the southeast (about 2000 ft) then it did to the north (about 1000 ft).

Data from all wells which experienced significant drawdown were plotted as drawdown vs log time and drawdown vs square-root of time-curves. A linear relationship between drawdown and log time was found for the pumping well and wells MW-9D and MW-10D. A linear relationship between drawdown and the square root of time was found for wells MW-7D, MW-11D and MW-15D. These results seem ~~to~~ indicate that the aquifer flow in the region of two former wells is toward the pumping well, whereas flow in the vicinity of the three latter wells is toward fracture(s).

Aquifer transmissivities computed using the Jacob method and data are summarized in Table 5-2. The transmissivities were computed directly from the semi-log plots given in Appendix H. (The plots given in Appendix H were chosen because of their high correlation coefficients.) Theis match results are similar and can be found in Appendix H. It should be noted that no values for the permeability of the aquifer are reported in these tables. Permeabilities are normally found by dividing the transmissivity by aquifer thickness. However, in a fractured bedrock aquifer, the aquifer thickness is not a well-defined parameter. Therefore, it is felt that it is more appropriate to leave the pump test results in terms of apparent transmissivity. Fracture permeability is likely to vary by several orders of magnitude, but on an area wide basis, we are interested in apparent transmissivity or the averaged ability to transmit water through a unit section of the aquifer.

Aquifer transmissivities computed using the Jenkins-Prentice method are summarized in Table 5-3. The plots of drawdown vs square-root of time are given in Appendix H. The distance of the observation wells from the fracture, ('x' in the Jenkins-Prentice equation) was found for the relevant wells by assuming that a major fracture (or fracture zone) passes through the pumping well location and strikes N45°E (southwest - northeast). The distances from the observation wells to this assumed fracture were then found by drawing the fracture on the site map and measuring orthogonal distances to relevant observation wells. It should be noted here that the Jenkins-Prentice method for finding transmissivity requires assumptions about fracture location. Because there is very little actually known about fracture locations at the Rocky Hill site and the actual pathways of flow to individual wells, the results of the Jenkins-Prentice method of analysis should not be considered very accurate. In this application the prime value of the

Jenkins-Prentice method lies in the fact that it indicates the areas in which flow may be linear (i.e. fracture - controlled and anisotropic) as opposed to radial.

The following conclusions are suggested by the pumping test results. First, a direct hydraulic connection between the shallow and the deep aquifer in the vicinity of the RHMW was not apparent during the 6 hour duration of the pump test. Second, flow in the aquifer as a result of pumping seems to occur in two different modes: linear flow toward fracture zone(s) and radial flow toward the pumping well. Third, the "radius of influence" of the pumping well extended further south (about 2000 ft) than it did north (about 1000 ft). Finally, the measured transmissivity of the bedrock aquifer from the Jacob method of analysis ranged from 7.9×10^3 to 9.4×10^3 gal/day/ft. Theis analysis results ranges from 6.4×10^3 to 7.8×10^3 gal/day/ft. The transmissivity as calculated using the Jenkins-Prentice method ranged from 3.3×10^3 to 6.4×10^3 gal/day/ft.

5.2.1.3 Permeability Tests. Upon completion of the installation of the wells, it was observed that for all wells the static water level occurred within the screened interval of the shallow wells or within the uncased open hole of the deep wells. In addition, several of the shallow wells were observed to be dry. Consequently, standard slug test procedures are inappropriate.

Data from the rising-head tests were reduced using equations developed by the Naval Facilities Engineering Command (1974) for determining permeability for shallow wells with various shape factors. The formula used has a shape factor which best fit the shallow monitoring wells installed. In this case,

$$K = \frac{R}{16DS} \times \frac{h_2 - h_1}{t_2 - t_1} \quad \text{for } \frac{D}{R} < 50$$

where K is the hydraulic conductivity; R is the well radius; D is the height of the water column in the well; S is the shape factor coefficient; h_1 is the depth to the water level at time t_1; and h_2 is the depth to the water level at time t_2. The shape factor coefficients were estimated using Figure 2.16 in U.S. Dept. of Navy (1974).

The data reduction method used for calculating strata permeabilities of the shallow wells is not applicable to the deep wells because of constraints on the shape factor. The Theis non-equilibrium method was used for calculating permeabilities for the deep wells.

Pumping rate was determined using data recorded during the slug test. W(u) was determined using the Theis curve matching technique.

Data from the slug tests were also entered into WCC's computer program SLUGT which computes the hydraulic conductivity using the method developed by Bouwer and Rice (1976). The permeability is calculated using the following formula:

$$K = \frac{r_c^2 \ \ln \ (R_e/rw)}{2 \ L \ t} \quad \ln \ \frac{Y_o}{Y_t}$$

where K is the hydraulic conductivity ; t is time, L is the length of screened section of well casing; r_c (corrected) is $[r+n\ (r_w{}^2 - r^2)]^{1/2}$ for the case where the water level occurs within the well screen of radius r and gravel pack of porosity n; Re is the effective radius over which the head difference is dissipated; values of Re are estimated using the Bouwer and Rice (1976) electrical resistance analog analysis; r_a is the horizontal distance between the well center and the undisturbed strata; and Y_o - Y_t is the vertical distance between the water level in the well after the removal of water and the equilibrium water level. Data for SLUGT program are shown in Appendix H.

Results of the slug test are summarized in Table 5-4. The agreement between the methods used on each well is very good. Wells MW-1S, MW-4S, MW-5S, MW-6S, MW-13S, and MW-15S were dry or contained too little water to perform slug tests. Wells MW-9S, MW-9D, MW-10S, MW-10D, MW-11S and MW-11D were under unsteady water level conditions prior to slug testing due to the influence from the pumping of the Rocky Hill municipal well. Data from wells MW-1D, MW-2S, MW-3D, and MW-5D were unreliable and were not evaluated by analytical methods.

5.2.2 Chemical Characteristics

5.2.2.1 In-Situ Measurements. Measurements of pH, electrical conductivity and temperature were obtained in the field at the time of ground water sampling, as described in Section 4.4.3. Results of these measurements are shown in Table 5-5.

The pH of the monitoring wells ranged from 5.0 in MW-4S airport to 12.2 in MW-3D. However, the high pH of MW-3D may be due to contamination of the ground water by cement grout, and the high conductivity of this well appears to corroborate this. Measured pHs of the monitoring wells do not appear to vary in any regular fashion across the site (Figure 5-7). The shallow monitoring wells are consistently of a lower pH than the paired deeper well.

Similarly, electrical conductivity and pH do not appear to vary regularly across the site. Deeper wells are generally 1 to 2 degrees cooler than the paired shallow well, but electrical conductivity is not consistently higher in either the deep or shallow of the paired wells.

5.2.2.2 Analytical Results. Twenty-three monitoring wells were included in the Round 1 sampling program. These samples were collected and analyzed as described in Section 4.4.3. Ground water samples were analyzed for priority pollutant compounds plus forty additional (tentatively identified) compounds. The results of these analyses are presented in Appendix G and discussed below.

The most common priority pollutant organic compound found in these ground water samples was trichloroethene. Other priority pollutant organic compounds found above detection limits included: trans-1,2-dichloroethene, tetrachloroethene, chloroform, acetone, methylene chloride, bis(2-ethylhexyl) phthalate, diethylphthalate, chlordane, and total phenols. Of these compounds, methylene chloride and bis (2-ethylhexyl) phthalate were also detected in the field and trip blanks, and acetone was used in field decontamination. This suggests that these compounds in ground water samples may be due to laboratory or field artifacts.

Trichloroethene in monitoring well samples ranged from below detection to 650 ug/l (Table 5-6). The highest TCE concentrations were detected in MW-7D and MW-7S. This well pair also contained significant (>20 ug/l) amounts of tetrachloroethene and trans-1,2-dichloroethene. More than 10 ug/l TCE was also detected in MW-2D, MW-3D, MW-3S, MW-4D, and MW-9D.

Explain TIC

The tentatively identified compounds detected in round one monitoring well samples are summarized in Appendix G. With few exceptions, the estimated concentrations of these compounds are less than 50 ug/l. One exception is 1,1,2-trichloro-1,2,2-trifluoroethane in MW-15D. All other tentatively identified compounds detected at more than 50 ug/l are associated with the field and trip blanks.

Several priority pollutant metals were found above detection limits in round one monitoring well samples. Analyses of ground water have been compared to drinking water standards to assist in summarizing the data. With the exception of monitoring well MW-3D, chromium is the only priority pollutant metal present in concentrations exceeding the National Primary Drinking Water Regulations (NPDWR) (Table 5-7). Chromium exceeded the NPDWR Maximum Contaminant Level (MCL) by less than a factor of 2 in two wells: MW-3S and MW-5D. Exceedances of NPDWR MCLs in MW-3D may be associated with the possible contamination of this well by grout and associated pH changes.

A number_of ground water samples from monitoring wells exceeded MCLs of the National Secondary Drinking Water Regulations (NSDWR) for the parameters analyzed under round one (Table 5-7). Nearly all wells exceeded these MCLs for iron and manganese. However, zinc MCL was not exceeded in any sampled well.

In general, there is no apparent correlation between the levels of organic compound contamination and priority pollutant metal contamination. For example, MW-7S and MW-7D were found to contain ground water with the highest TCE concentration, but no priority pollutant metal in these wells exceeded the NPDWR MCLs. Conversely, MW-3S and MW-5D contained chromium above the NPDWR MCL, but only MW-3S contained a detectable concentration of TCE.

Ternary diagrams of major inorganic constituents in ground water are shown in Figures 5-8 and 5-9. These diagrams were constructed by converting the concentrations of calcium, magnesium, sodium and potassium to equivalents per liter, and then normalizing these values to 100 percent. Ground water analyses from the shallow and the deep monitoring wells occupy two distinct fields on these diagrams. In general, the ground water from shallow wells is depleted in calcium and contains more sodium plus potassium relative to the deep wells. The extremely high calcium value of MW-3D may be due to contamination by grout. The sodium enrichment in the shallow wells may be due to the effect of road salting on the shallow aquifer. The chemical distinction between the shallow and deep wells suggests that chemical mixing is incomplete, and therefore, shallow and deep parts of the aquifer are not in full communication.

5.3 DOMESTIC WELL INVESTIGATION

5.3.1 In-Situ Measurements

Thirty-five domestic wells were included in Round 1 of sampling. Measurements of pH, electrical conductivity and temperature were obtained from domestic well water samples as described in Section 4.4.4. The field measurement data in Table 5-5 are the final measurements collected after well purging, and represent the closest approach to stabilized values of these parameters. The measured pH of domestic wells ranged from 5.77 to 11.65, and there is no apparent trend in pH, conductivity, or temperature across the site.

5.3.2 Analytical Results

Domestic wells were analyzed for full priority pollutants plus forty (tentatively identified compounds), and analytical results are presented in Appendix G.

The principal priority pollutant organic compound found in domestic wells is TCE, and concentrations ranged from below detection to 340 ug/l. A total of 17 out of 35 wells sampled was found to contain more than 4 ug/l TCE, and 9 wells contained more than 50 ug/l. Results from this round of analyses are consistent with previous investigations (Table 5-8). Although TCE concentrations in the most recent round of analyses are not identical to the previous results, they are generally within a factor of 2 to 3. The areas of highest TCE contamination found in earlier investigations (the end of Oxford Circle, near the end of Robin Drive, and Cleveland Circle) are approximately the same as in this study.

Other priority pollutant organic compounds detected in the domestic wells include: 1,1 dichloroethane, tetrachloroethene, 1,1,1 trichloroethane, methylene chloride, acetone, di-n-butylphthalate, diethyl phthalate, ethylbenzene, toluene, chloroform, chlordane, bromodichloromethane and total phenols. Of these compounds, methylene chloride, acetone, and di-n-butylphthalate were also detected in the field or trip blanks. Tentatively identified compounds in domestic well samples are included in Appendix G.

Priority pollutant metals were detected in a number of the domestic wells. Wells in which these metals exceeded NPDWR MCLs are shown in Table 5-9. Exceedances of NSDWR MCLs are also included on this table. Exceedances of these standards were found for lead (3 wells), chromium (1 well), silver (1 well), iron (3 wells) and manganese (4 wells). There is no apparent relationship between organic contamination and priority pollutant metals exceedance. The wells also do not appear to have any explainable relationship with each other with respect to the metals concentrations.

TABLE 5-1
GROUND WATER ELEVATIONS AND MONITORING WELL DATA

Monitoring Well	Elev. of Outer Casing (ft)	Elev. of Inner Casing (ft)	Approx. Height of Riser (ft)	Ground Elev. (ft)	Total Depth of Well (ft)	11 July 1986 Depth to Water TOC (ft)	11 July 1986 Ground Water Elev. (ft)	3 Nov 1986 Depth to Water TOC (ft)	3 Nov 1986 Ground Water Elev. (ft)	13 Dec 1986 Depth to Water TOC (ft)	13 Dec 1986 Ground Water Elev. (ft)
MW-1S	101.97	102.60	1.10	99.5	19.5	17.93	82.67	20.38	80.22	8.69	91.51
MW-1D	101.93	101.45	1.95	99.5	150.0	38.52	62.93	38.93	62.52	35.44	66.01
MW-2S	51.19	61.09	-0.31	61.4	21.0			14.09	47.00	11.09	50.02
MW-2D	61.64	61.34	-0.06	61.4	150.0			22.32	39.02	18.70	42.64
MW-3S	142.71	142.64	0.84	141.8	64.5	50.78	91.86	53.71	88.93	47.38	95.26
MW-3D	143.42	143.02	1.22	141.8	96.0	50.97	92.05	54.86	88.16	48.19	94.83
MW-4S	124.24	123.43	0.63	122.8	19.5			dry		dry	
MW-4D	123.14	122.91	0.11	122.8	150.0			21.93	100.98	20.09	102.82
MW-5S	142.75	141.73	0.13	141.6	36.0			dry		dry	
MW-5D	142.26	142.07	0.47	141.6	150.0			49.71	92.36	40.55	101.52
MW-6S	147.24	146.94	1.04	145.9	40.0			39.59	107.35	36.02	110.92
MW-6D	148.17	147.74	1.84	145.9	100.0			41.96	105.78	37.86	109.88
MW-7S	146.04	145.26	1.46	143.8	41.5	35.07	110.19	37.64	107.62	31.36	113.90
MW-7D	145.50	145.26	1.46	143.8	150.0	38.46	106.80	43.41	101.85	34.87	110.39
MW-9S	151.63	150.29	0.49	149.8	46.5	41.48	108.81	48.37	101.92	43.36	106.27
MW-9D	151.96	151.88	2.08	149.8	250.0	76.09	75.79	88.96	62.92	46.54	105.34
MW-10S	154.41	153.50	1.80	151.7	46.5	43.39	110.11	dry		44.86	109.55
MW-10D	153.02	152.75	1.05	151.7	250.0	71.81	80.94	no meas.		46.66	106.09
MW-11S	132.35	129.98	1.98	128.0	25.0			dry		18.10	111.88
MW-11D	129.81	126.84	0.84	128.0	250.0			47.57	81.27	23.18	106.63
MW-13S	113.37	111.81	1.21	110.6	20.0	21.28	90.53	21.62	90.19	9.47	103.90
MW-13D	112.42	112.13	1.53	110.6	250.0	26.83	85.30	33.46	78.67	17.46	94.67
MW-14S	75.82	74.71	1.61	73.1	19.0			15.55	59.16	4.85	70.97
MW-14D	74.63	73.73	0.63	73.1	150.0			13.83	59.90	12.76	60.97
MW-15S	126.25	125.50	1.60	123.9	25.5	26.56	98.94	dry		16.04	109.46
MW-15D	125.20	124.88	0.98	123.9	250.0	27.53	97.35	41.02	83.86	19.22	105.66
RSMW	153.84									52.00	101.84

MTH 001 0673

TABLE 5-2

TRANSMISSIVITY FROM PUMP-TEST DATA BY JACOB METHOD

Well	Stage	Apparent Transmissivity gal/day/ft
MW-9D	Drawdown	7.3×10^3
MW-9R	Recovery	8.1×10^3
MW-10D	Drawdown	8.5×10^3
MW-10D	Recovery	9.4×10^3
Pumping Well	Drawdown	8.9×10^3
Pumping Well	Recovery	8.1×10^3

TABLE 5-3

TRANSMISSIVITY FROM PUMP-TEST DATA BY JENKINS-PRENTICE METHOD

Well	Stage	Apparent Transmissivity gal/day/ft
MW-7D	Drawdown	3.3×10^3
MW-11D	Drawdown	6.4×10^3
MW-15D	Drawdown	4.4×10^3

TABLE 5-4
PERMEABILITY TEST RESULTS (ft/sec)

Well Number	Hydraulic Conductivity 1* (ft/sec)	Hydraulic Conductivity 2** (ft/sec)
MW-2D	2.3×10^{-7}	3.8×10^{-6}
MW-3S	1.2×10^{-6}	N/A
MW-4D	2.6×10^{-6}	1.5×10^{-5}
MW-6D	5.2×10^{-6}	2.5×10^{-5}
MW-7S	1.3×10^{-5}	N/A
MW-7D	9.9×10^{-6}	1.4×10^{-5}
MW-13D	8.4×10^{-7}	4.5×10^{-6}
MW-14D	2.5×10^{-6}	4.3×10^{-6}
MW-15D	6.4×10^{-7}	3.8×10^{-6}

* Conductivity 1 - Using method of Theis (1935) for deep wells and method of U.S. Dept. of Navy (1974) for shallow wells

** Conductivity 2 - Using method of Bouwer and Rice (1976)

N/A Not Available

TABLE 5-5
IN-SITU CHEMICAL MEASUREMENTS

Well		Date	pH (Std. Units)	Conductivity (umho/cm)	Temp. (°C)
	Domestic Wells (1)				
1555	Canal Road	6/6/86	6.84	275	18
1565	Canal Road	6/6/86	7.31	220	16.5
1575	Canal Road	6/6/86	7.28	225	16
1585	Canal Road	6/6/86	7.28	155	16.5
1643	Canal Road	6/6/86	7.56	225	15
11	Cleveland Circle	6/6/86	6.90		10.5
19	Cleveland Circle	6/6/86	7.47		5.3
28	Cleveland Circle	6/6/86	11.05		9.5
31	Montgomery Road	6/6/86	7.35		9.6
59	Montgomery Road	6/6/86	11.65		9.3
67	Montgomery Road	6/6/86	8.35		9.8
124	Montgomery Road	6/6/86	8.3		9.7
171	Montgomery Road	6/6/86	7.58		10.0
188	Montgomery Road	6/6/86	8.2		12.1
22	Oxford Circle	6/5/86	6.75	245	15
32	Oxford Circle	6/5/86	8.68	145	16
36	Oxford Circle	6/5/86		220	14.5
	Research Road	6/6/86	6.78	225	14.5
15	Robin Drive	6/6/86	7.44	335	16
27	Robin Drive	6/5/86	6.59	290	14
34	Robin Drive	6/5/86	6.71	210	14.5
48	Robin Drive	6/5/86	5.99	105	16
58	Robin Drive	6/5/86	6.74	105	15.5

(1) In-situ measurements of domestic wells are final readings after purging well.

TABLE 5-5 (Continued)
IN-SITU CHEMICAL MEASUREMENTS

Well		Date	pH (Std. Units)	Conductivity (umho/cm)	Temp. (°C)
Domestic Wells[1]					
1434	Route 206	6/5/86	6.52	170	15
1475	Route 206	6/6/86	7.39	180	15.5
1501	Route 206	6/5/86	6.37	260	15
3	Sycamore Lane	6/5/86	7.82		12.0
21	Sycamore Lane	6/5/86	7.95		12.1
22	Sycamore Lane	6/5/86	7.55	230	11.9
41	Sycamore Lane	6/5/86	7.50		12.1
46	Sycamore Lane	6/5/86	7.67		11.7
66	Sycamore Lane	6/5/86	5.77		9.6
81	Sycamore Lane	6/5/86	6.63		12.5
85	Sycamore Lane	6/5/86	7.39		15.0
86	Sycamore Lane	6/5/86	7.40		13.9
Monitoring Wells					
MW-1D		11/18/86	7.8	480	10
MW-1S		11/18/86	6.4	360	12
MW-2D		12/4/86	7.6	272	8.5
MW-2S		12/4/86	6.8	208	12
MW-3D		12/4/86	12.2	4160	6
MW-3S		11/20/86	6.0	78	7
MW-4D Airport		12/4/86	7.5	336	10
MW-4S Airport		11/20/86	5.0	57	11
MW-4D		11/21/86	5.9	78	10
MW-5D Airport		12/4/86	7.5	288	11
MW-5D		11/21/86	6.1	50	11.5
MW-6D		11/20/86	6.9	65	5
MW-65		11/21/86	dry		
MW-7D		11/18/86	5.5	460	9
MW-7S		11/18/86	5.2	460	9
MW-9D		11/19/86	6.5	200	8
MW-9S		11/19/86	dry		
MW-10D	---				
MW-10S		11/21/86	7.2	78	11
MW-11D		12/3/86	6.9	148	10.0
MW-11S		12/3/86	5.6	104	9
MW-13D		11/20/86	6.8	48	10

TABLE 5-5 (Continued)
IN-SITU CHEMICAL MEASUREMENTS

Well	Date	pH (Std. Units)	Conductivity (umho/cm)	Temp. (°C)
Monitoring Wells				
MW-13S	11/19/86	6.5	80	11
MW-14D	12/3/86	6.4	168	10.5
MW-14S	12/3/86	5.6	184	9
MW-15D	11/21/86	7.5	160	11

MTH 001 0679

TABLE 5-6
TCE CONTENTS OF MONITORING WELLS

Well	TCE Concentration 11/18/86-11/21/86, 12/3/86-12/4/86 (ug/l)
MW-1D	ND
MW-1S	ND
MW-2D	34
MW-2S	ND
MW-3D	ND
MW-3D dup.	13
MW-3S	320
MW-4D	240
MW-4D airport	ND
MW-4S airport	ND
MW-5D	ND
MW-5D airport	ND
MW-6D	ND
MW-7D	650
MW-7S	650
MW-9D	6.3
MW-9D dup.	6.3
MW-10D	ND
MW-11D	ND
MW-11S	ND
MW-13D	ND
MW-13S	ND
MW-14D	ND
MW-14S	ND
MW-15D	

ND: Not Detected at Detection Limit of 5 ug/l.

TABLE 5-7
PRIORITY POLLUTANT METALS IN MONITORING WELLS IN EXCEEDANCE OF NPDWR AND NSDWR

	NPDWR[1] (MCL)	MW-3D	MW-3D (dupl.)	MW-3S	MW-5D
Arsenic	50		186		
Barium	1,000	1,660	2,300		
Cadmium	10				
Chromium	50	304	406	90	60
Lead	50	686	786		
Mercury	2				
Selenium	10				
Silver	50				

	NSDWR[2] (MCL)	Monitoring Wells in Exceedance of MCL
Iron	300	all except MW-7D, MW-14S
Manganese	50	all except MW-7D, MW-10D, MW-11D, MW-13S, MW-14S, MW-15D
Zinc	5,000	none

All concentrations in ug/l.

1 National Primary Drinking Water Regulations, Maximum Contaminant Levels, 40 CFR 141

2 National Secondary Drinking Water Regulations, Maximum Contaminant Levels, 40 CFR 143

TABLE 5-8

TCE CONTENTRATION IN DOMESTIC WELLS:

SUMMARY OF RECENT AND PREVIOUS ANALYSES

Well		TCE Concentration, Previous Investigations [1] (ug/l)	TCE Concentration 6/5/86 - 6/6/86 (ug/l)
11	Cleveland Circle	>150	140
19	Cleveland Circle	>150	60
28	Cleveland Circle	>150	72
31	Montgomery Road	-	ND
59	Montgomery Road	-	ND
67	Montgomery Road	-	ND
124	Montgomery Road	-	ND
171	Montgomery Road	1-24	58
188	Montgomery Road	-	1.9
22	Oxford Circle	1-24	72
32	Oxford Circle	-	64
36	Oxford Circle	50-99	220
	Research Road	-	ND
15	Robin Drive	ND	28
27	Robin Drive	1-24	46
34	Robin Drive	>150	340
48	Robin Drive	100-149	86
58	Robin Drive	1-24	ND
1434	Route 206	-	ND
1475	Route 206	ND	ND
1501	Route 206	ND	ND

1 Data summarized in RAMP and reproduced in Figure 3-5

RB87-133tb

TABLE 5-8 (Continued)

TCE CONTENTRATION IN DOMESTIC WELLS:
SUMMARY OF RECENT AND PREVIOUS ANALYSES

Well		TCE Concentration, Previous Investigations[1] (ug/l)	TCE Concentration 6/5/86 - 6/6/86 (ug/l)
3	Sycamore Lane	-	35
21	Sycamore Lane	50-99	40/44[2]
22	Sycamore Lane	1-24	24
41	Sycamore Lane	1-24	2.5
46	Sycamore Lane	1-24	32
66	Sycamore Lane	ND	ND
81	Sycamore Lane	ND	3.9
85	Sycamore Lane	1-24	18
86	Sycamore Lane	1-24	3.8

2 Duplicate sample

ND Not Detected

\- Not Analyzed

RB87-133tb

TABLE 5-9

PRIORITY POLLUTANT METALS IN DOMESTIC WELLS

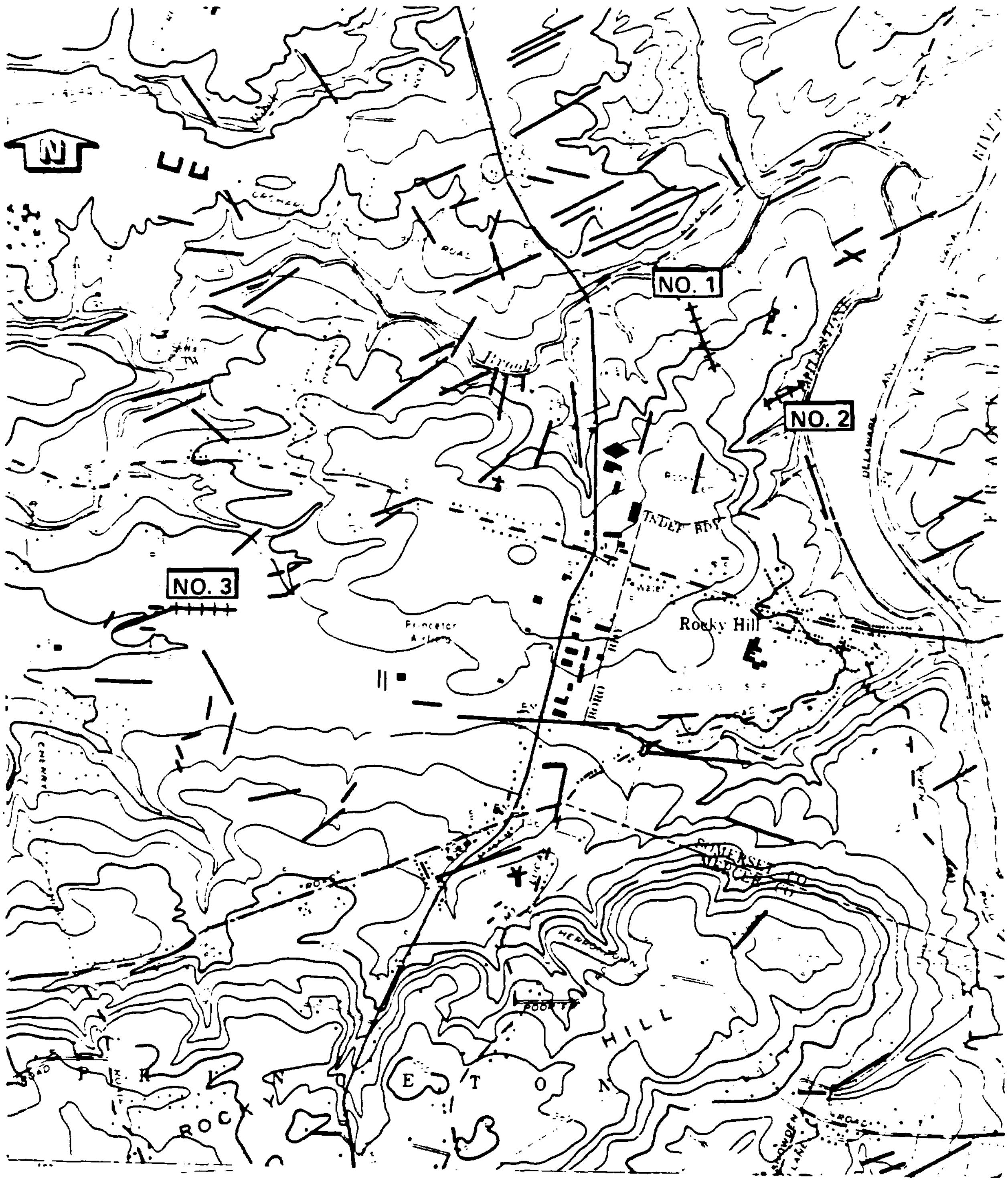
IN EXCEEDANCE OF NPDWR AND NSDWR

	NPDWR[1] (MCL)	NSDWR[2] (MCL)	1585 Canal	31 Montgomery	59 Montgomery	15 Robin	27 Robin	34 Robin	48 Robin	1475 Rte 206	3 Sycamore	21 Sycamore
Arsenic	50											
Barium	1,000											
Cadmium	10											
Chromium	50									117		
Lead	50						143		2,170		740	
Mercury	2											
Selenium	10											
Silver	50		180									
Iron		300			3,840			656				510/514[3]
Manganese		50		295	222	94	74					
Zinc		5,000										

All concentrations in ug/l

1 National Primary Drinking Water Regulations, Maximum Contaminant Levels, 40 CFR 141.
2 National Secondary Drinking Water Regulations, Maximum contaminant Levels, 40 CFR 143.
3 Duplicate Samples.

RB87-133tc



0 2500 5000 FT
SCALE

LEGEND

— LINEAMENTS INDICATED BY AERIAL PHOTOS

+++ LINEAMENT INVESTIGATED BY GEOPHYSICAL SURVEY

◆ FRACTURE OR FRACTURED ZONE DETECTED BY GEOPHYSICAL SOUNDINGS

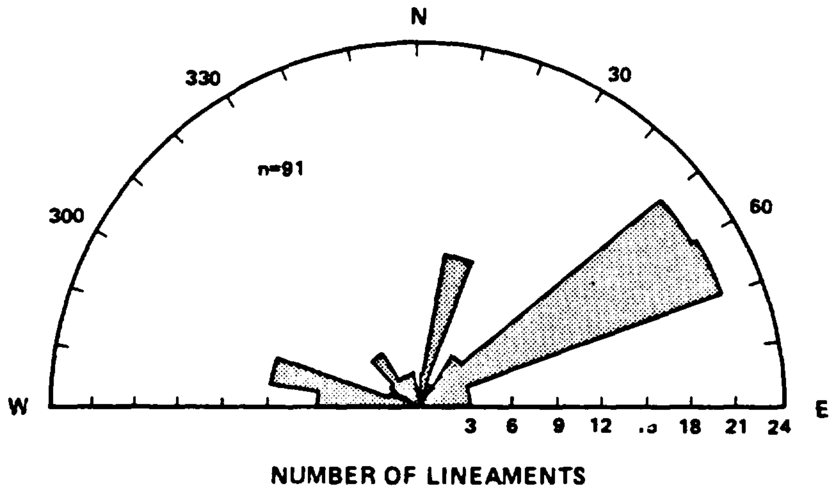
MAP SOURCE:

USGS MAP, ROCKY HILL QUADRANGLE
7.5 MINUTE SERIES (TOPOGRAPHIC)
PHOTOREVISED 1970

LOCATION OF LINEAMENTS
MTHD/RHMW SITE
SOMERSET COUNTY, NEW JERSEY

WOODWARD—CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR. BY: PS	SCALE: AS SHOWN	PROJ. NO.: 86C4290
CK'D. BY: NLB	DATE: 3 DEC. 1985	FIG. NO.: 5–1

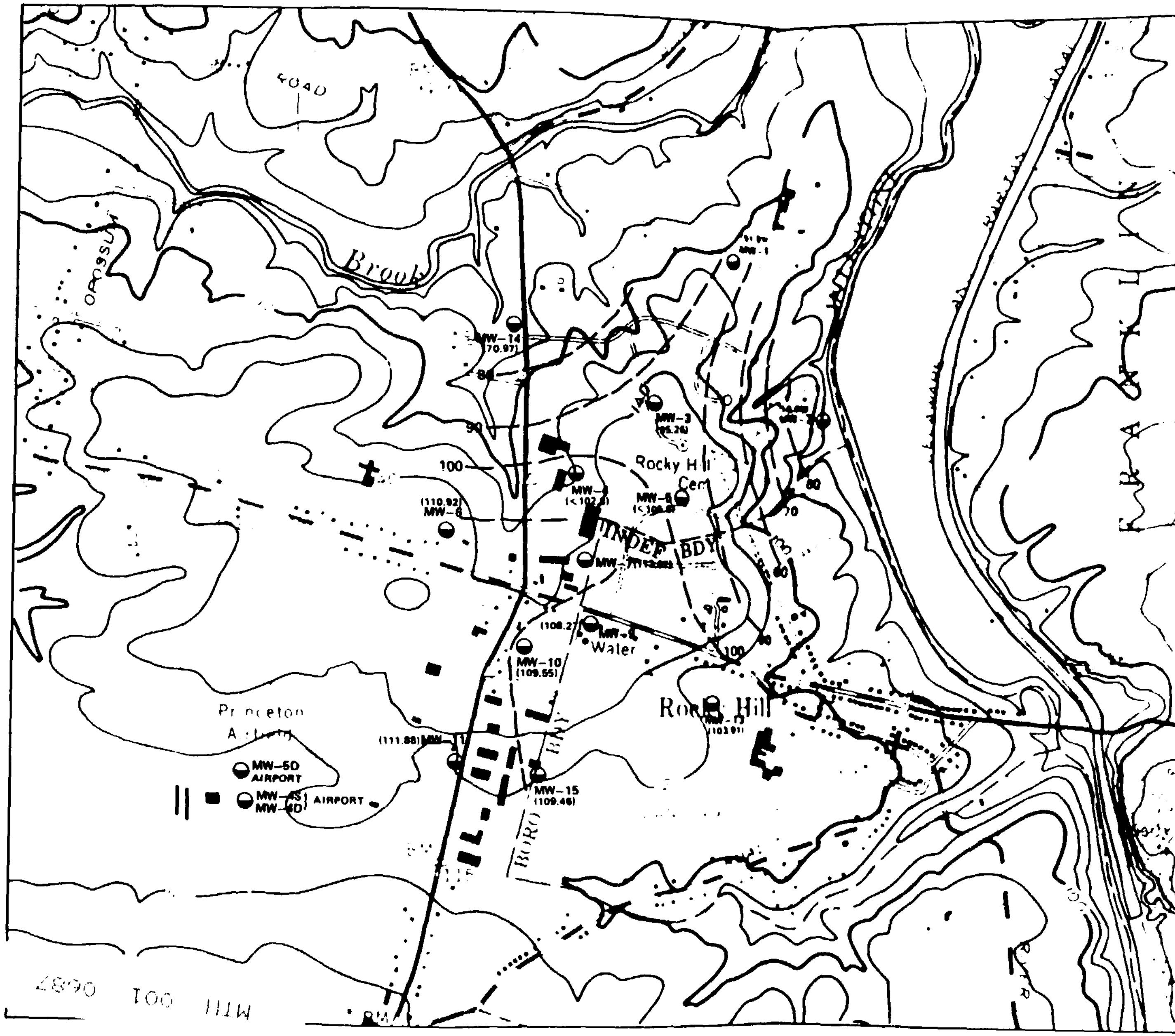


ORIENTATION OF LINEAMENTS
MTHD/RHMW SITE
SOMERSET COUNTY, NEW JERSEY

WOODWARD—CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR. BY: RL	SCALE: AS SHOWN	PROJ. NO.: 86C4290
CK'D. BY: NLB	DATE: 26 NOV 1985	FIG. NO.: 5-2

0690 100 1111



LEGEND

MW-6 MONITORING WELL LOCATION AND NUMBER

(109.61) WATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL

—60— PIEZOMETRIC SURFACE CONTOUR (CONTOUR INTERVAL 10 FT)

SOURCE:
USGS MAP 7.5 MINUTE SERIES,
ROCKY HILL QUADRANGLE,
NEW JERSEY, DATED 1970

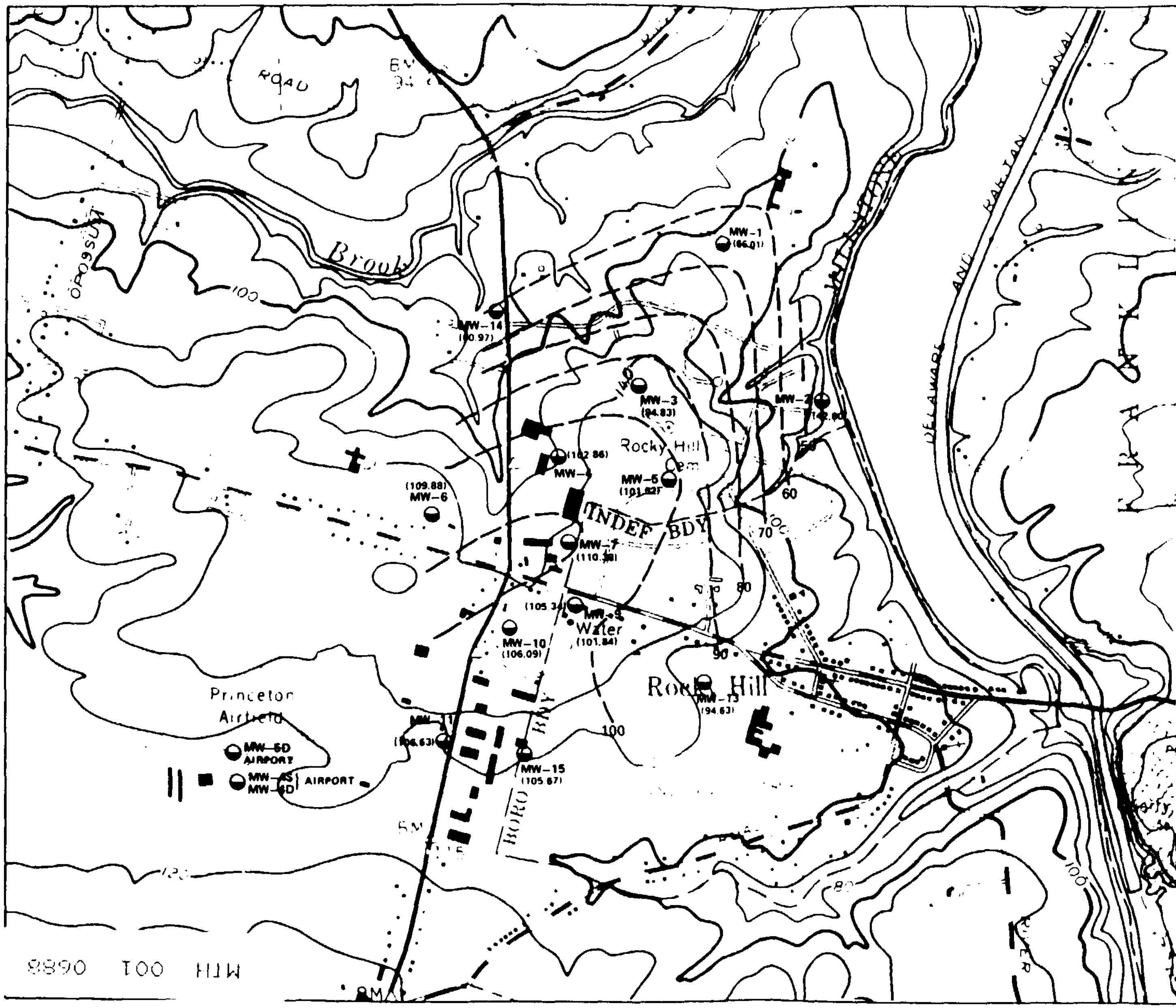
0 1000 2000 FT
SCALE

STATIC WATER ELEVATIONS IN SHALLOW WELLS
13 DECEMBER 1986

WOODWARD - CLYDE CONSULTANTS
CONSULTING ENGINEERS GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE NEW JERSEY

DR BY	DRS	SCALE	AS SHOWN	PROJ NO	86C4290
CKD BY	EC	DATE	19 JUNE 1987	FIG NO	5-3

MTH 001 0687



LEGEND

MW-6 MONITORING WELL LOCATION AND NUMBER

(101.2) WATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL

—60— PIEZOMETRIC SURFACE CONTOUR (CONTOUR INTERVAL 10 FT)

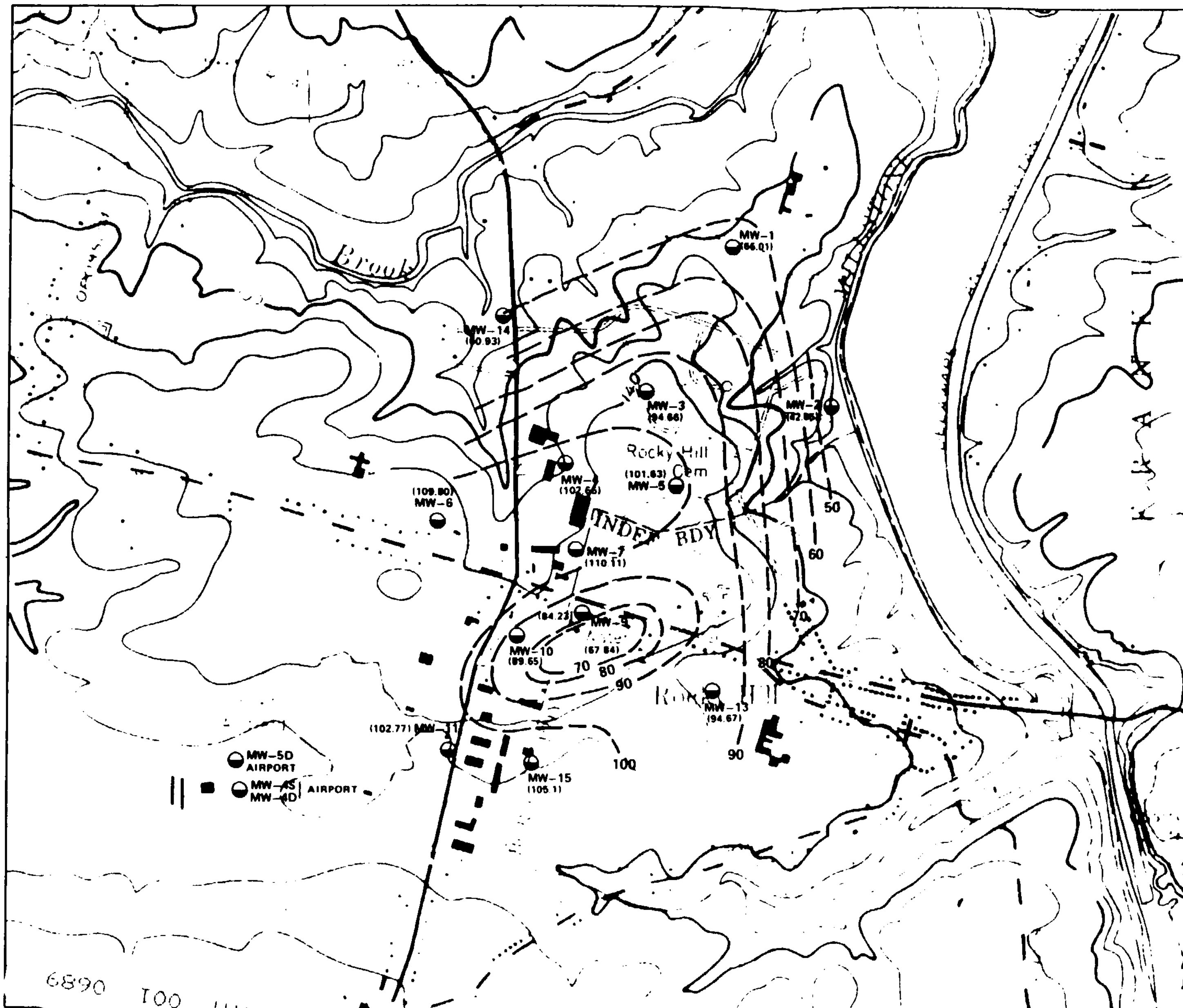
SOURCE
USGS MAP 7.5 MINUTE SERIES,
ROCKY HILL QUADRANGLE,
NEW JERSEY, DATED 1970

0 1000 2000 FT
SCALE

STATIC WATER ELEVATIONS IN DEEP WELLS
13 DECEMBER 1986

WOODWARD - CLYDE CONSULTANTS
CONSULTING ENGINEERS GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE NEW JERSEY

DR BY	DRS	SCALE	AS SHOWN	PROJ NO	86C4290
CK'D BY	EC	DATE	19 JUNE 1987	FIG NO	5-4



N

LEGEND

MW-6 MONITORING WELL LOCATION AND NUMBER

(109.61) WATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL

—60— PIEZOMETRIC SURFACE CONTOUR (CONTOUR INTERVAL 10 FT)

SOURCE:
USGS MAP 7.5 MINUTE SERIES,
ROCKY HILL QUADRANGLE,
NEW JERSEY, DATED 1970

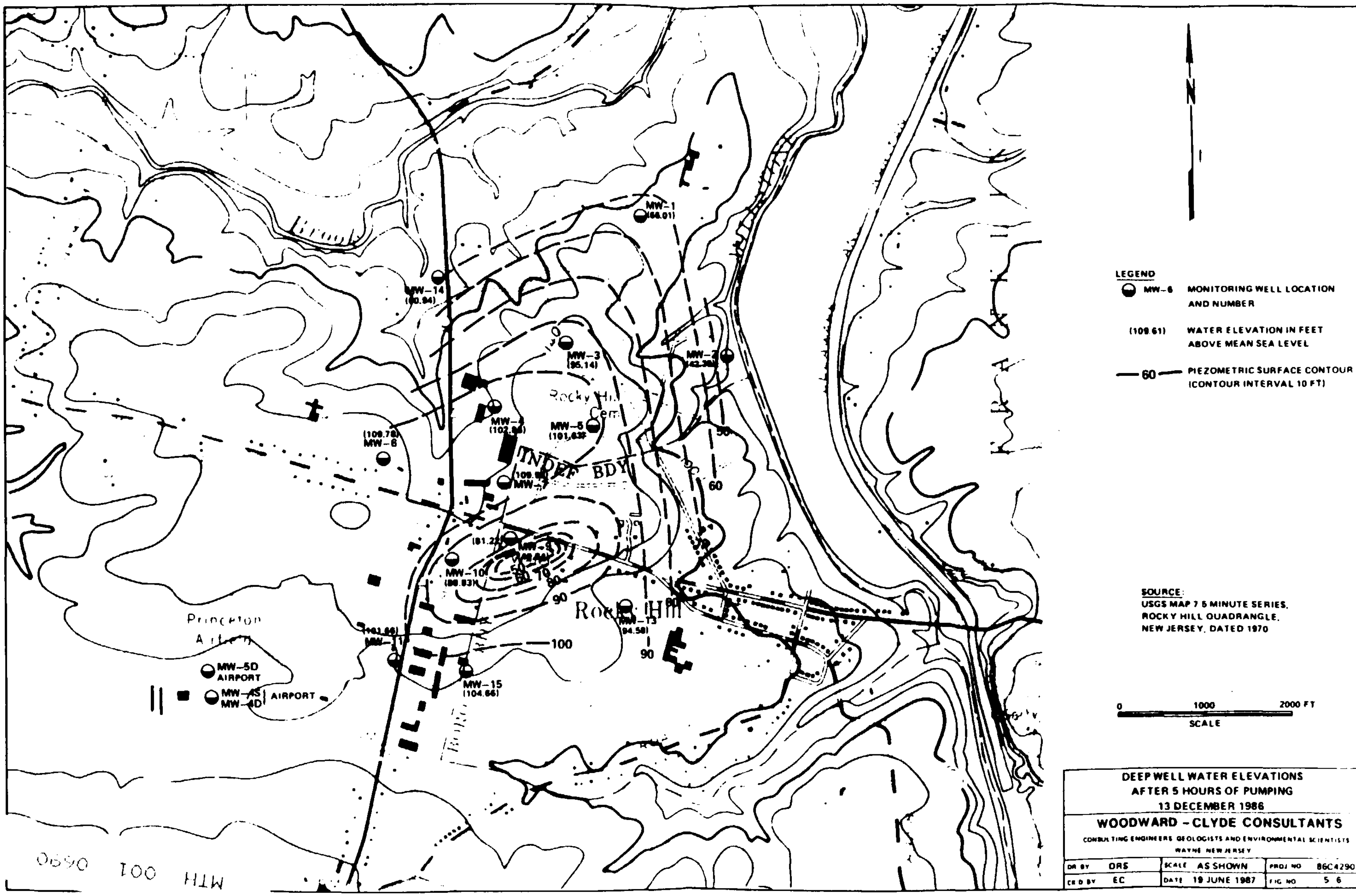
0 1000 2000 FT
SCALE

DEEP WELL WATER ELEVATIONS
AFTER 3 HOURS OF PUMPING
13 DECEMBER 1986

WOODWARD – CLYDE CONSULTANTS

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR BY	DRS	SCALE	AS SHOWN	PROJ NO	86C4290
CK'D BY	EC	DATE	19 JUNE 1987	FIG NO	5-5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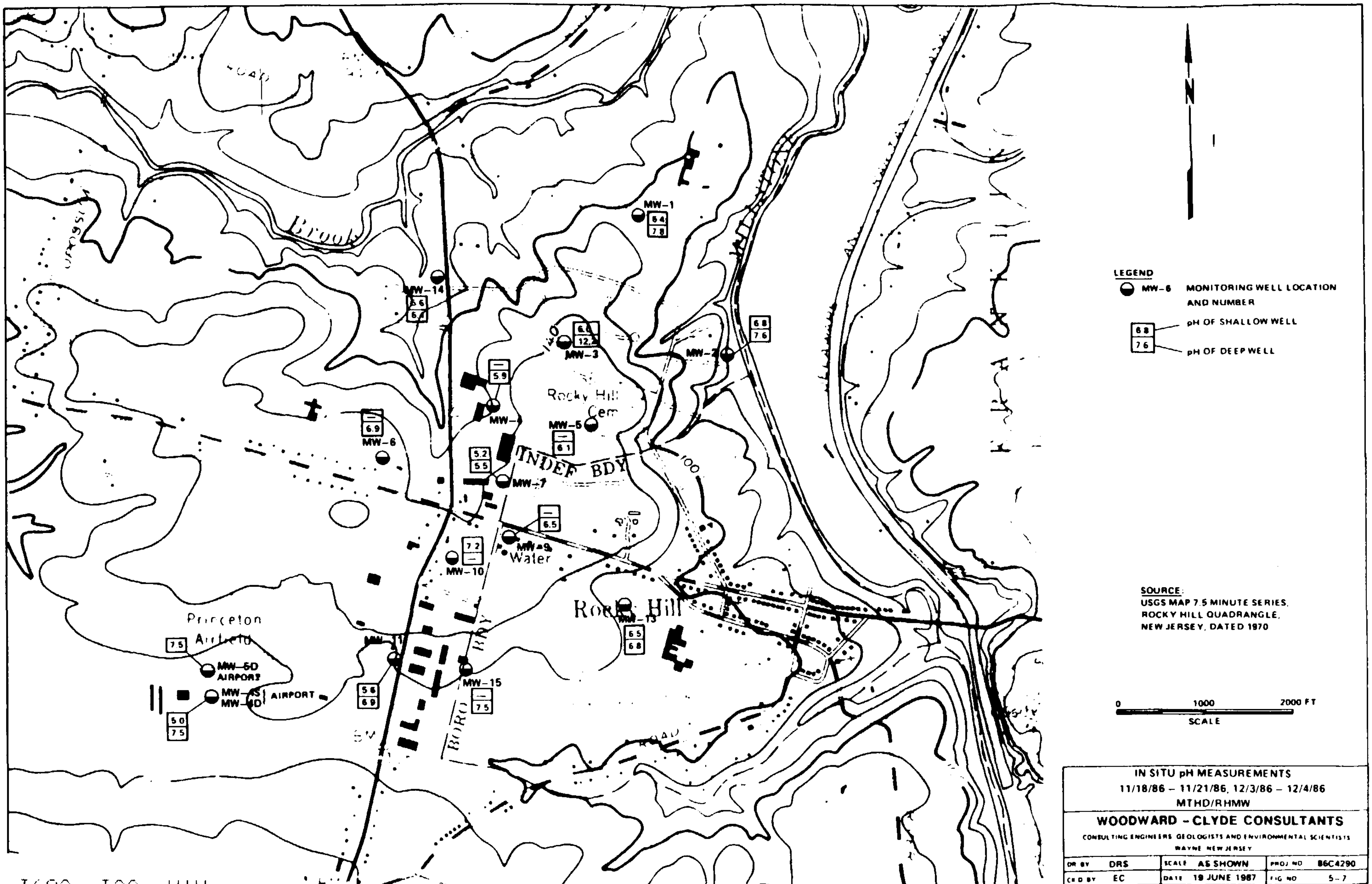
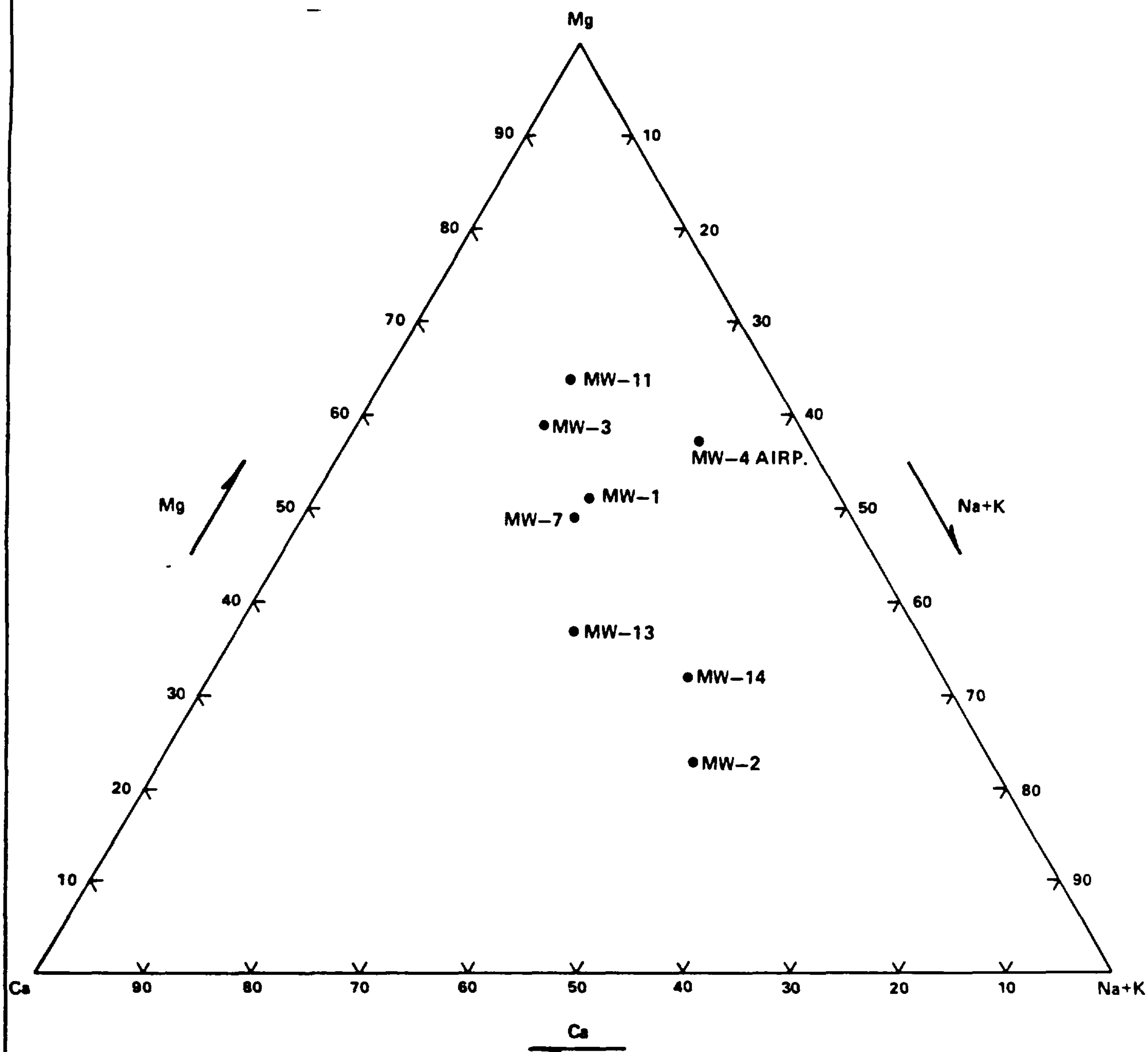
LEGEND
MW-6 MONITORING WELL LOCATION AND NUMBER
(109.61) WATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL
60 PIEZOMETRIC SURFACE CONTOUR (CONTOUR INTERVAL 10 FT)
SOURCE:
USGS MAP 7 5 MINUTE SERIES, ROCKY HILL QUADRANGLE, NEW JERSEY, DATED 1970
0 1000 2000 FT
SCALE
MW-1
(66.01)
MW-14
MW-3
(95.14)
MW-2
MW-4
MW-5
(109.78)
MW-6
MW-7
MW-10
(86.83)
MW-13
(94.58)
MW-11
MW-15
(104.66)
MW-5D
AIRPORT
MW-4S
MW-4D
AIRPORT
Rocky Hill
Cem
Rocky Hill
Princeton
Airport
50
60
90
100
DEEP WELL WATER ELEVATIONS
AFTER 5 HOURS OF PUMPING
13 DECEMBER 1986
WOODWARD - CLYDE CONSULTANTS
CONSULTING ENGINEERS GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE NEW JERSEY
DR BY ORS
SCALE AS SHOWN
PROJ NO 86C4290
CKD BY EC
DATE 19 JUNE 1987
FIG NO 5 6

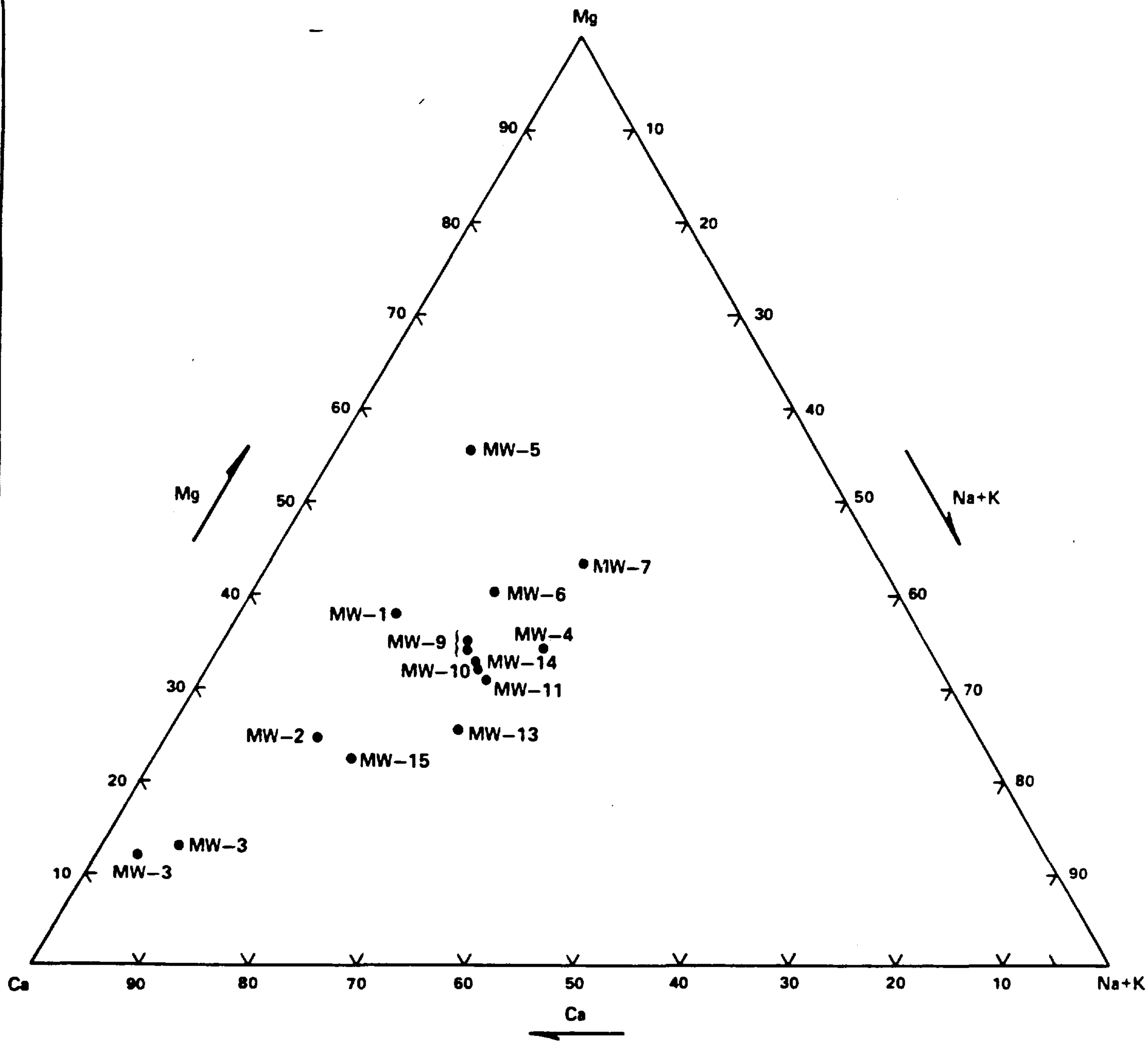

N
LEGEND
MW-6 MONITORING WELL LOCATION AND NUMBER
6.8 pH OF SHALLOW WELL
7.6 pH OF DEEP WELL
SOURCE:
USGS MAP 7.5 MINUTE SERIES,
ROCKY HILL QUADRANGLE,
NEW JERSEY, DATED 1970
0 1000 2000 FT
SCALE
MW-1 6.4 7.8
MW-2 6.8 7.6
MW-3 6.6 12.2
MW-4 5.9
MW-5 6.1
MW-6 6.9
MW-7 5.2 5.5
MW-9 6.5
MW-10 7.2
MW-11 5.6 6.9
MW-13 6.5 6.8
MW-14 5.6 6.4
MW-15 7.5
MW-5D AIRPORT 7.5
MW-4S MW-4D 5.0 7.5
AIRPORT
Rocky Hill Cem
Rocky Hill
Princeton Airfield
Brook
Water
IN SITU pH MEASUREMENTS
11/18/86 – 11/21/86, 12/3/86 – 12/4/86
MTHD/RHMW
WOODWARD - CLYDE CONSULTANTS
CONSULTING ENGINEERS GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE NEW JERSEY
DR BY DRS
SCALE AS SHOWN
PROJ NO 86C4290
CKD BY EC
DATE 19 JUNE 1987
FIG NO 5-7



MTHD/RHMW
SHALLOW WELLS

TERNARY DIAGRAM PERCENTAGES ON BASIS OF EQUIVALENTS PER LITER					
WOODWARD - CLYDE CONSULTANTS CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS WAYNE, NEW JERSEY					
DR. BY	DRS	SCALE	AS SHOWN	PROJ NO	86C4290
CK'D BY	EC	DATE	8 JUNE 1987	FIG NO	5-8

MTH 001 0692



MTHD/RHMW
DEEP WELLS

MHI 001 0693

TERNARY DIAGRAM PERCENTAGES ON BASIS OF EQUIVALENTS PER LITER					
WOODWARD - CLYDE CONSULTANTS CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS WAYNE, NEW JERSEY					
DR BY:	DRS	SCALE:	AS SHOWN	PROJ NO	86C4290
CK'D BY:	EC	DATE:	5 JUNE 1987	FIG NO	5-9

SECTION SIX
SITE CHARACTERIZATION SUMMARY

6.1 GEOLOGY

The Montgomery Township Housing Development Hill Municipal Well site is underlain by siltstone, claystone and mudstone of the Brunswick Foundation. The Brunswick is a heterogeneous unit, and beds of calcareous siltstone, argillaceous limestone and dolostone have also been identified.

The upper portion of the Brunswick Formation is deeply weathered clay and rock (shale) fragments, and it is overlain by a surficial deposit (generally less than 4 ft) of sand, silt, clay and gravel. The Brunswick Formation tends to increase in competency with depth.

The Brunswick Formation in this area is observed to strike N40°E to N50°E and dip gently to the NW about 10 to 15°. The lineament study in this area concluded that most of the fractures in the bedrock are not bedding plane joints, but rather sets of fractures at an acute angle to bedding. The predominant trend of fractures was found to average N60°E; the inclination of these joints is uncertain. However, if this fracture set can be associated with a water saturated fracture system identified by geophysical soundings in the area between Route 206 and Robin Drive (see Section 5.1.1), this fracture set may be nearly vertical. Nevertheless, the geophysical survey also identified some near-horizontal fracture zones, which may be associated with the bedding planes.

Nearly all of the porosity in the Brunswick Formation is fracture porosity. Although the distribution of fractures with depth in the Brunswick Formation is not known, the inventory of existing monitoring and water supply wells in the Montgomery Township/Rocky Hill site (Table 3-1) suggests that water-bearing zones persist to a depth of at least 500 ft. The high yields produced by these wells are further evidence of extensive deep fracture systems.

6.2 HYDROLOGY

As mentioned above, ground water beneath the site primarily resides within the fracture porosity of the Brunswick Formation, the principal regional aquifer. Shallow and deep monitoring wells were installed within this aquifer in order to investigate conditions in the aquifer, including:

- depth to ground water,
- ground water gradients,
- quality of the ground water,
- aquifer properties,
- degree of connectivity between upper and lower parts of the aquifer,
- potential for vertical flow, and
- flow rates.

Depth to ground water in the shallow wells (screened in the weathered top of bedrock) was found to range from approximately 5 to 54 ft below ground surface. Deeper wells (to depths of 100 to 250 ft) uniformly exhibited lower piezometric heads than the paired shallow well, indicating a potential for downward vertical flow of ground water.

Contours of ground water elevations and piezometric head appear concordant with the topographic contours in the MTHD. Ground water is generally deepest under topographic highs. Ground-water flow in both the shallow and deep aquifers appears to be toward the Millstone River and Beden Brook. The shallow aquifer intersects and discharges to the Millstone River and Beden Brook and to several small streams which are tributaries of the Millstone River and Beden Brook.

Ground water flow (Darcy) velocities may be calculated for the area of the Montgomery Township Housing Development well by applying the equation:

$$V_D = \frac{KI}{n}$$

where V_D is the ~~Darcy~~ Seepage velocity, K is the hydraulic conductivity, I is the gradient, and n is the porosity. This assumes porous medium equivalent flow, which becomes more appropriate as the ratio of aquifer thickness to lateral extent decreases. WCC considers this assumption to be valid when evaluating flow over a large area.

Using a typical gradient for the piezometric surface of the deep wells of .03 (Section 5.2.1.1) and a maximum permeability of 1.5×10^{-5} ft/sec based on the slug test data (Section 5.2.1.3), the maximum Darcy velocity is 142 ft/year. The minimum measured conductivity of 6.4×10^{-7} ft/sec results in a Darcy velocity of 6 ft/year. These calculations assume a porosity of .10, which is typical of shale (Driscoll, 1986). Similar calculations based on shallow well data produce Darcy velocities of 11 ft/year and 123 ft/year.

Although the potential for vertical flow exists, evidence for extensive downward flow from the upper to the lower levels of the aquifer is limited. Evidence against extensive communication between the aquifers tapped by the shallow and deep wells is twofold: pump test results and major cation geochemical analyses. As discussed in Section 5.2.1.2, pumping of the Rocky Hill Municipal Wells caused drawdowns in the deep wells, but none of the shallow wells appeared to be affected during the period of pumping. This indicates that the continuity of fractures between the shallow and deep aquifers is limited, at least within the radius of influence, or approximately 1000 to 2000 ft of the pumping well. Similarly, as discussed in Section 5.2.2.2, the ground water from the shallow and deep wells appears to be geochemically fairly distinct with respect to the major dissolved cations. This chemical distinction suggests that extensive mixing between the deep and shallow zones of the aquifer is not occurring, at least in the vicinity of wells MW-1, MW-2, MW-11 and MW-14. However, the ground water chemistry (and TCE concentration) appear to be similar between deep and shallow levels of the aquifer at MW-7, suggesting that some vertical communication in the aquifer may be present at least near that location. In addition, the persistence of ground water contamination to depths of 250 ft (the depth of the deepest monitoring wells) indicates that some degree of vertical communication in the aquifer must occur at least locally.

6.3 CONTAMINANT MIGRATION

Private septics

A summary of ground water TCE contents obtained during WCC's Round 1 sampling program is illustrated in Figure 6-1. Although other organic contaminants have been detected in monitoring and domestic wells, TCE will be used as an indicator parameter in this discussion because the most complete data are available for TCE. Figure 6-1 illustrates an arcuate plume of ground water contamination which extends from RHMW approximately northward to Sycamore Lane, and from Route 206 eastward to the Millstone River. The boundaries of the plume can not be precisely defined due to the wide spacing (up to 1,000 ft or more) between wells. The maximum TCE contamination has been observed in wells MW-7S and MW-7D, and high levels of contamination follow a trend from this well set north-northeast to MW-3S and MW-3D, and thence eastward through the ends of Oxford Circle and Cleveland Circle. In general, TCE concentrations decrease from MW-7 to the south and to the north and east.

Comparing the shape of the contaminant plume (Figure 6-1) and the ground water contours after 3 hours of pumping (Figure 5-5) and without pumping (Figures 5-3 and 5-4), it appears that the shape of the contaminant plume is to some extent consistent with the inferred ground water flow directions. In the MTHD, the part of the plume passing beneath Oxford Circle and Cleveland Circle is approximately parallel to the expected east-northeastward direction of ground water flow. This is consistent with both pumping and non-pumping conditions in the deep and shallow wells. From approximately MW-7 to the south, ground-water contours during pumping indicate that flow is toward the RHMW. This suggests that the contaminant plume may have been extended to the south by capture of the pumping well.

The difference in ground water elevations between MW-4 and MW-14 indicate that ground water in the northwestern part of the MTHD would tend to flow to the north or northwest. This area is near the apparent "bend" in the plume. Based on ground water elevations alone, it is unclear why the contaminant plume did not in part continue to migrate northward toward Beden Brook. (Note that the northern most TCE detected was in the Sycamore Lane residence wells.) The absence of contamination to the north may be explained by a number of possibilities:

- o The northeast-trending ground water divide shown on Figures 5-3 to 5-6 is actually farther to the north, and the contaminant plume does not cross the divide.

- o The contaminant plume is more strongly attenuated to the north due to variations in lithology and is no longer detectable in ground water after it passes the Sycamore Lane area.

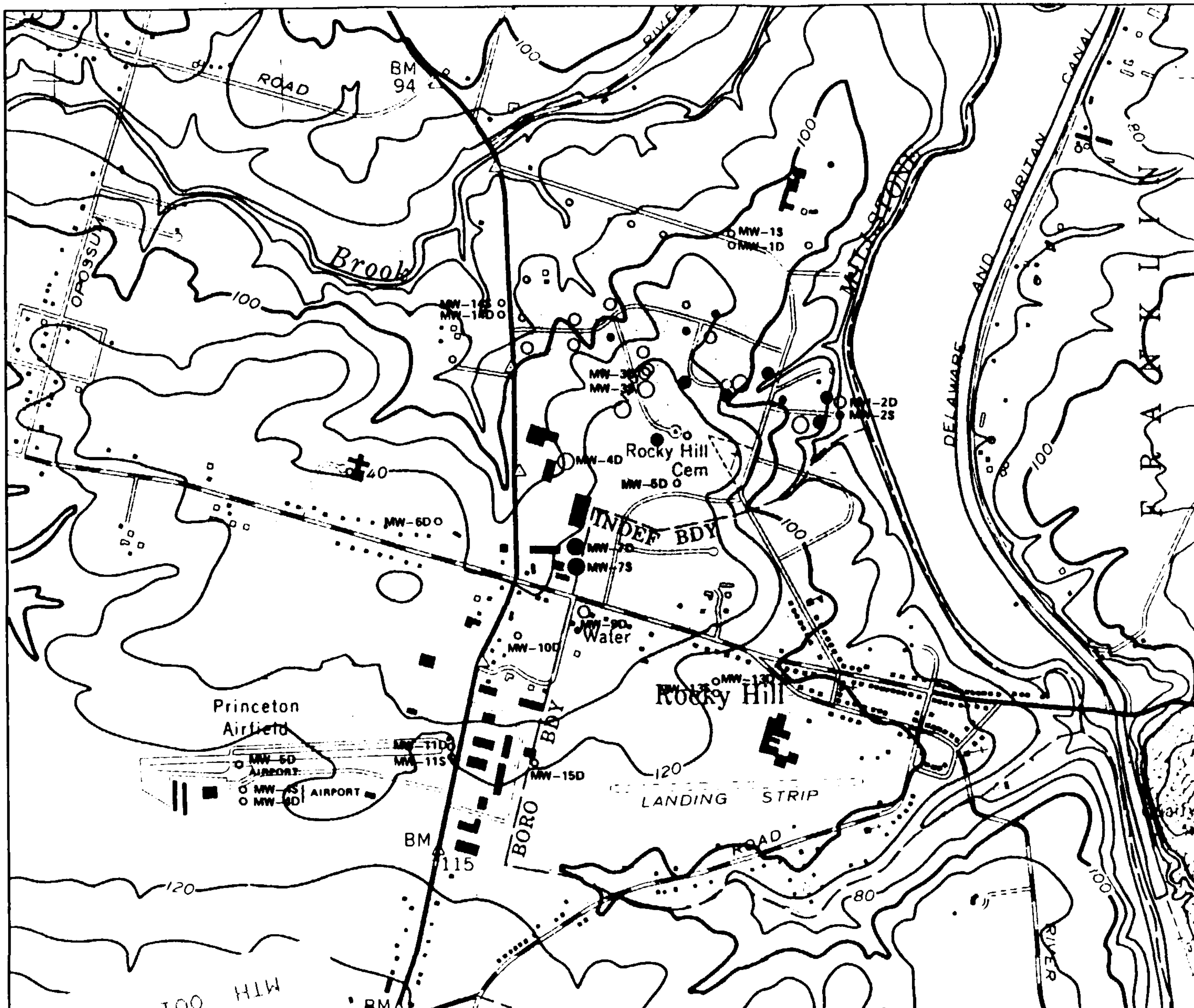
- o Anisotropy in the aquifer is marked, and east-northeast trending fractures parallel to the northeastern limb of the plume preferentially transport the contamination in a narrow pathway toward the Millstone River. In contrast, the connectivity or density of northward-trending fractures may be limited, as suggested by the lineament study. Thus the pathways for contaminant flow northward toward Beden Brook may be restricted.

- o Because of the likely anisotropy of the aquifer and the lesser permeability in the northwesterly direction, it is possible that the leading edge of the plume to the north may not yet have migrated much beyond Sycamore Lane.

The shape of the plume in the area of the housing development agrees, in general, with earlier investigations. However, in detail, the TCE concentrations in most of the individual wells have fluctuated through time without any apparent pattern. For example, at 34 Robin Drive, the TCE concentration has increased from 39 ug/l in 1979 to 340 ug/l in 1986, whereas TCE in the neighboring domestic well at 58 Robin Drive went from 2 ug/l in 1979 to 950 ug/l in 1982 to ND in 1986. (See Volume 2 Appendix A.) There does not appear to be any overall temporal trend with respect to TCE concentration in wells, i.e., there is no evidence that ground water quality in the entire MTHD is either improving or deteriorating through time since sampling began in 1979.

These data suggest that although there are perturbations over time in the contaminant plume on the scale of a few hundred feet, the plume overall has appeared to be at a steady state for at least the last 8 years (1979 to 1987). This apparent state may be due to two conditions: (1) the source or sources of contamination have been constant since at least before 1979, or (2) the source or sources of contamination are no longer present but the rate of contaminant migration is so slow that the plume has not yet been appreciably dispersed. The maximum likely ground-water velocity calculated in Section 6.2 is 143 ft/year; assuming that longitudinal dispersion and retardation are not significant effects (or that they cancel each other) and that only horizontal migration occurs, the maximum distance that a slug of water would have traveled in the past 10 years is about 1500 ft. The minimum possible horizontal distance under similar assumptions is about 60 ft in 10 years, and the plume is over 8,000 to 10,000 ft in length. Based on these rough approximations, it is not possible to rule out either condition 1 or condition 2.

Vertical contaminant migration is evidenced by the presence of TCE in deep and shallow wells throughout the extent of the plume. In particular, identical TCE concentrations (650 ug/l) were detected at MW-7D and MW-7S, the point of maximum observed contamination. Because the ground-water elevations suggest flow from shallow to deep levels in the aquifer, a shallow contaminant source which migrated both downward and laterally is indicated.



LEGEND

TRICHLOROETHENE CONCENTRATIONS

- NOT DETECTED
- ND-5 ppb
- 5-50 ppb
- 50-100 ppb
- 100-500 ppb
- > 500 ppb

NOTE:
SEE FIGURE 4-1 FOR LOCATIONS OF MONITORING WELLS AND DOMESTIC WELLS

SOURCE:
USGS MAP 7.5 MINUTE SERIES, ROCKY HILL QUADRANGLE, NEW JERSEY, DATED 1970

0 1000 2000 FT
SCALE

TCE CONCENTRATIONS
ROUND ONE GROUND WATER SAMPLES
MTHD/RHMW

WOODWARD - CLYDE CONSULTANTS

CONSULTING ENGINEERS GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE NEW JERSEY

DR BY	DRS	SCALE	AS SHOWN	PROJ NO	86C4290
CKD BY	EC	DATE	19 JUNE 1987	FIG NO	6-1

MTH 001 0701

SECTION SEVEN
CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

Conclusions drawn from this remedial investigation are summarized below.

1. The site is underlain by a fractured bedrock aquifer which consists of an upper unconfined section and a lower semi-confined section with downward vertical communication existing between the two.

2. Ground-water flow is toward the NE in the eastern part of the MTHD and to the NW in the northwestern part of the MTHD with shallow water discharging directly into surface water bodies.

3. There is no definable vertical distribution pattern of contaminants.

4. The areal extent of contamination is bounded roughly by:

   - Canal Road on the east
   - Montgomery Avenue on the north
   - Route 206 on the West
   - Montgomery Township Line on the South and that section of Route 518 between the line and Route 206

5. TCE has been detected in the area defined above, ranging from detection limits (5 ug/l) up to 650 ug/l. Other halogenated hydrocarbons have also been observed. [and changed to 950 ? In FS

6. Based on calculated ground-water velocities it is not possible to determine whether the source or sources of contamination is/are

continuing to emit contaminants or whether the source or sources is/are no longer present.

7. Based on the present distribution of contaminants and ground-water flow patterns and the assumption that conditions now are not appreciably different than in the past, several PRPs can be eliminated as possible sources of contaminants: Ingersoll Rand, Compo Industries, Princeton Volkswagen and Princeton Airport.

7.2 RECOMMENDATIONS

Although this study has eliminated several possible sources of contaminants, a single source or group of sources has not been defined. Continued study needs to be focused on the area at the upgradient (SW) end of the plume. WCC is currently undertaking a soil and water sampling program in this area. Recommendations with regard to health risks are included in the Feasibility Study (Volume 2) of this report.

7.3 LIMITATIONS

It is recognized that WCC's work is in accordance with our understanding of professional practice and environmental standards existing at the time the work was performed. Professional judgments presented herein are based on our evaluation of technical information gathered and on our understanding of site conditions and site history. Our analyses, interpretations and judgments rendered are consistent with professional standards of care and skill ordinarily exercised by the consulting community and reflect the degree of conservatism WCC deems proper for this project at this time. Methods are constantly changing and it is recognized that standards may subsequently change because of improvements in the state of the practice.

The information used for this work is presented in this report and includes resistivity surveys, boring logs, water level elevations, and water quality analyses. Boring logs reflect subsurface conditions for the indicated locations and dates. Water quality samples represent only a small portion of the pertinent subsurface conditions in the area, both in volume and through time. The interpretations made in this report are based on the assumption that subsurface conditions do not deviate appreciably from those found during our field investigations.

We have assumed that the Brunswick Formation acts as a porous medium equivalent and meets the classical definitions of unconfined and semi-confined aquifers. The Brunswick is an aquifer that is composed of numerous separate and/or connected zones of fractures that vary in spacing, density and interconnection. While it may not appear to meet the conditions for aquifer analysis, evaluation of cores, field observation of water levels and examination of the shape of curves from the pumping test imply that the aquifer zones approximate a porous medium equivalent. As the ratio of aquifer thickness to areal extent becomes smaller, and horizontal flow predominates over vertical flow, the system comes closer to meeting the porous medium limitations. Thus, for the site as a whole, analytical methods based on porous medium flow can be appropriate.

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